

SEDAP

A PROGRAM FOR RESEARCH ON

SOCIAL AND ECONOMIC DIMENSIONS OF AN AGING POPULATION

An Inventory of Canadian Microsimulation Models

**Yann Décarie
Michaël Boissonneault
Jacques Légaré**

SEDAP Research Paper No. 298

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The Program for Research on Social and Economic Dimensions of an Aging Population (SEDAP) is an interdisciplinary research program centred at McMaster University with co-investigators at seventeen other universities in Canada and abroad. The SEDAP Research Paper series provides a vehicle for distributing the results of studies undertaken by those associated with the program. Authors take full responsibility for all expressions of opinion. SEDAP has been supported by the Social Sciences and Humanities Research Council since 1999, under the terms of its Major Collaborative Research Initiatives Program. Additional financial or other support is provided by the Canadian Institute for Health Information, the Canadian Institute of Actuaries, Citizenship and Immigration Canada, Indian and Northern Affairs Canada, ICES: Institute for Clinical Evaluative Sciences, IZA: Forschungsinstitut zur Zukunft der Arbeit GmbH (Institute for the Study of Labour), SFI: The Danish National Institute of Social Research, Social Development Canada, Statistics Canada, and participating universities in Canada (McMaster, Calgary, Carleton, Memorial, Montréal, New Brunswick, Queen's, Regina, Toronto, UBC, Victoria, Waterloo, Western, and York) and abroad (Copenhagen, New South Wales, University College London).

An Inventory of Canadian Microsimulation Models

Abstract

The first aim of this document was to produce the most complete list as possible of the microsimulation models developed in Canada in the last two decades. Moreover, information was provided about the people or entities that participated in their production, as well as about the researchers who used them and the papers in which they were mentioned. All these informations were found online, more particularly on the web pages of the various workshops of the International Microsimulation Association (IMA) as well as on Statistics Canada's Internet page.

Keywords: Microsimulation, Canada, Statistics Canada.

Un inventaire des modèles de microsimulation canadiens

Résumé

Le but premier de ce document est de dresser la liste la plus complète possible des modèles de microsimulation produits au Canada dans les deux dernières décennies. Des informations sont également fournies à propos des personnes ou entités ayant participé à leur production, sur les chercheurs qui en ont fait usage, ainsi qu'à propos des ouvrages dans lesquels ces modèles ont été mentionnés. Toute l'information qu'on y trouve a été trouvée en ligne, notamment sur les pages des différents ateliers de l'International Microsimulation Association (IMA) ainsi que sur le site web de Statistique Canada.

Mots clés : Microsimulation, Canada, Statistique Canada.

JEL Classification: C150, C600

AN INVENTORY OF CANADIAN MICROSIMULATION MODELS¹

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Summary

Introduction.....	3
Chapter 1: Canada’s Federal Corporate Income Tax: A Microsimulation Model.....	5
Chapter 2: The Canadian Tax and Credit Simulator (CTaCS)	7
Chapter 3: Demosim.....	11
Chapter 4: Dynacan	16
Chapter 5: Lifepaths	20
Chapter 6: Persim	35
Chapter 7: The Population Health Model (POHEM).....	38
Chapter 8: The Riskpaths Teaching Model	44
Chapter 9: Ruthen	47
Chapter 10: The Social Policy Simulation Database and Model (SPSD/M)	50
Chapter 11: Experimental Economy Theoretical Growth Model (XEcon).....	54
Chapter 12: Other Models.....	56

¹ A document prepared and financed by the Population Change and Lifecourse Strategic Knowledge Cluster and presented at their 2011 Computer Modeling Seminar, Gatineau, Québec, Canada

Introduction

The present document aims to give an overview of some of the most commonly used microsimulation models that have been developed in the past two decades in Canada. Most of the models described below were developed by Statistics Canada, but we also found some that were developed by researchers working for other Government departments or universities for example. This document was made to give the reader a good overview of those models but at the same time to allow him to find some specific information such as who has worked on which model and the type of researches involved. Having that in mind, the present document was written in the following manner:

- The document is divided into 13 chapters, where each chapter presents one model. The length of the chapters varies according to the amount of information found on each model, thus giving an idea of the extend to which it was used or worked on: the models are presented in alphabetical order and a chapter called *Other Models* – thus containing several models – completes the list.
- For each model the designer is first presented, i.e. the organization or person(s) who developed it, and – if found – the year of creation. A summary description of the model, which usually comes from the designer, is followed.
- The following section lists the names of all the researchers who produced at least one paper or made at least one presentation where the model in question was used or described (either solely or along with other models). Furthermore, the affiliation corresponding to each user is presented in parenthesis. However, this affiliation may not be accurate at the moment of writing these lines since an individual may have moved to another entity while updates were not available. Most often, the affiliation attributed corresponds to the one the researcher belonged to when the paper in which he was author or co-author was produced.

- The last section usually contains the most information for every model. It gives an overview of the papers or presentations that were either using or describing a given model. To do so, a few lines or paragraphs describing the work done are taken from the corresponding papers or presentations which is usually the abstract, summary or a part of the introduction for instance. Finally, a few lines describe – if found – the results of the given studies which are also textually taken from those papers or presentations. In every case, notes in the bottom of the page give the complete reference including the authors' names and the Internet address where the information was found.

Our first approach was to consider all information on the different models and users which could be found on the web pages of the program at the workshops of the International Microsimulation Association (IMA) which took place in 2007, 2009 and 2011. Statistics Canada's webpage "Microsimulation"² was also very useful in this respect. Complementary information about the models, the papers or presentations and the researchers was found on different websites or in online documents. The references can be found in notes at the bottom of the pages.

It is important to keep in mind that this document may be incomplete and may not cover all the information on microsimulation models in Canada. Any suggestions regarding omissions or incomplete information will be welcomed³.

² <http://www.statcan.gc.ca/microsimulation/index-eng.htm>.

³ Please send an email to Yann Décarie at: yann.decarie@ucs.inrs.ca

Chapter 1: Canada's Federal Corporate Income Tax: A Microsimulation Model

Designer: Department of Finance Canada, 2000

Description:

One of the analytical tools used by Canada's Department of Finance to measure the impact of changes on the corporate tax system is microsimulation modelling (MSM). There have been a number of changes in the corporate tax system since 2000, changes that are recent examples of the application of MSM. In particular, the elimination of the capital tax and the reduction of the general federal corporate income tax rate from 29.12% (including the surtax) in 2000 to 19% in 2009 (and to 15% by 2012) are instances where MSM was of great value in measuring the impact on government revenues and on the various sectors of the economy. The paper will describe the microsimulation model and the data used by the Department. It will also cover some technical aspects of the model having to do with multivariate analysis⁴.

Users:

- Bailey, Earl (Canada Revenue Agency)
- Li, Wei (Canada Revenue Agency)
- Lu, Wen Fong (Canada Revenue Agency)

Applications:

1. *The effects of Population Ageing on the Personal Income Tax Revenue in Canada: A Simulation Approach*

The Canadian population has been ageing since the 1980s with the proportion of Canadians age 65 and over continuing to increase to the middle of the century. It is envisioned that population ageing will have implications on both the government's expenditure and revenue sides. This paper focuses on the revenue implications. The major objective of the paper is to profile the ageing of the population and illustrate how it will affect the patterns of personal income and taxes at the federal level. The research is based on the Statistics Canada medium population growth projection over the period 2000 to 2026 and applying these projections to a micro-simulation model developed by the Canada Revenue Agency to make projections of federal personal income tax. Our major findings include: In the case of the demographic approach that assumes only population structure change, the total personal taxable income and the total net federal income tax over the period 2001 to 2026 will continue to increase, but the average taxable income and income tax payable per return will

⁴ Statistics Canada, "Canada's Federal Corporate Income Tax: A Microsimulation Model", *International Microsimulation Association 2009, Abstracts – Session 1B*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1b-eng.htm#a30>.

show a decline from 2011 when the “baby boomers” reach their retirement age. In the case of the combined demographic and income approach under the assumptions that both population will change structurally and that personal income will increase, the average taxable income and income tax payable per return will continue to increase over the whole projection period, but that the growth rate of income tax revenue is expected to slow down after 2011⁵.

2. *Government of Canada, Tax Expenditures 1999*

Paper's Abstract:

The majority of the personal income tax estimates in this report were computed with a personal income tax model. This model simulates changes to the personal income tax system using the statistical sample of tax returns collected by Revenue Canada for its annual publication *Taxation Statistics*. The model estimates the revenue impact of possible tax changes by recomputing taxes payable on the basis of adjusted values for all relevant income components, deductions and credits. For example, the removal of the moving expense deduction would result not only in a change in net income but also in all of the credits, such as the medical expense tax credit, whose values depend on net income. For those tax expenditures whose costs could not be estimated using this model alone, supplementary data were acquired from a variety of sources. Details on data sources and the methodologies used for estimating the cost of specific personal income tax measures are provided in Chapter 4⁶.

⁵ Wen Fong Lu, W. Li, E. Bailey, 2005. “The effects of Population Ageing on the Personal Income Tax Revenue in Canada: A Simulation Approach”, *Canada Revenue Agency*, http://www.psc.ntu.edu.tw/outline/e_paper/pop30/30_2.pdf, p. 29-30.

⁶ Department of Finance Canada, *Government of Canada, Tax Expenditures 1999*, <http://www.fin.gc.ca/taxexp-depfisc/1999/taxexp99e.pdf>.

Chapter 2: The Canadian Tax and Credit Simulator (CTaCS)

Designer: Kevin Milligan, economist at the University of British Columbia, 1998, re-written in 2003-04

Description:

The Canadian Tax and Credit Simulator (CTaCS) is a package that simulates the Canadian personal income tax and transfer system. It makes use of the [Stata](#) software package. In addition to the simulator, the CTaCS package includes a database of tax and transfer parameters dating from 1962 to 2005.

You can use CTaCS to:

- Assign tax burdens and refundable credit entitlements for microdata samples.
- Simulate the tax burden at different income levels, family types, years, or provinces.
- Look up tax parameters such as federal tax brackets and rates, provincial tax rates, and credit and deduction levels. What was the per-child deduction limit for childcare expenses in 1972? CTaCS knows!
- Assist in teaching a course in taxation, whether in economics, law, accounting, or other fields⁷.

Users:

- Bibi, Sami (Université Laval)
- Clavet, Nicholas-James (Université Laval)
- Duclos, Jean-Yves (Université Laval)
- Fortin, Bernard (Université Laval)
- Kromann, Lene (Aarhus University)
- Lacroix, Guy (Université Laval)
- Milligan, Kevin (University of British Columbia)
- Stabile, Mark (University of Toronto; Rimini Center for Economic Analysis (RCEA))

Applications:

1. *Impact of child care support on female labor supply, family income and public finance*

Paper's Abstract:

We study in this paper the impact of child care support on female labor force participation, family income, and public finance in Quebec (Canada). We first estimate the determinants of female labor supply using a conditional logit. We then simulate the effects of withdrawing existing child care support measures (federal tax deduction, provincial tax credit and child care in-kind support) and of the im-

⁷ Milligan, K., *Canadian Tax and Credit Simulator: CTaCS*, <http://faculty.arts.ubc.ca/kmilligan/ctacs/learn.htm>.

plementation of recent and alternative child care support measures. Outcomes are heterogeneous with family structure and child care support measures. The results show that child care support has a significant effect on female labor supply, family income and public finance. The federal tax deduction, the provincial tax credit and in-kind child care support increase female labor supply and family income but deteriorate public finance. Withdrawing child care support totally would induce a significant fall in labor supply and in family income and an improvement in public finance. Finally, a universal child care allowance would increase labor supply and family income but would worsen public finance the opposite effect would be observed following a reduction in in-kind child care support⁸.

2. *Essays on Productivity and Labour Supply*

Paper's Summary:

The fourth and final chapter is joint work with professor Benoit Dostie, HEC Montreal. In this chapter, we estimate income- and substitution- labour supply and participation elasticities for Canadian married women using data for 1996-2005. We use the Canadian Tax and Credit Simulator (CTaCS) and detailed information on the structure of income at the household level to compute the marginal tax rates faced by each individual. We then use these marginal tax rates to compute net own-wage, spouse-wage, and non-labour income. Finally, because marginal tax rates vary significantly over the sample, we use quantile regressions to compare elasticities at different points of the hours distribution. We find that taking taxation into account yields significantly lower labour supply elasticities. We further provide evidence that labour supply elasticities became closer to zero the last 10 years. Finally, we find that labour supply elasticities are much larger for wives working the fewest hours. In fact, once past the median number of hours of work, the estimated elasticities are basically zero for all three hours of work elasticities. Overall, our results show that public policies have, on average, today lower scope for influencing hours of work than 10 years ago. Still, the quantile results show that wives working less hours per week are more sensitive to changes in their own or spouse wages. Thus, if there is to be any scope in increasing working hours, the focus should be on these low-hours working wives⁹.

3. *Évaluation de l'Avis du CCLP – Rapport remis à la Direction générale adjointe de la recherche, de l'évaluation et de la statistique*

Avant de procéder à l'estimation des modèles économétriques d'offre de travail, il est nécessaire de modéliser les prestations d'assistance-sociale et le revenu après impôts pour différents choix d'heures travaillées. Le montant d'aide sociale versée a été déterminée en suivant le Règlement sur le soutien du revenu de 2004. De plus, plusieurs variables ont été imputées en fonction des caractéristiques individuelles : valeur du compte bancaire, dettes, actifs financiers, voiture (si propriétaire), et valeur nette de la résidence (si propriétaire). Le revenu après impôt est modélisé à l'aide du logiciel Canadian Tax and Credit Simulator (CTaCS). Une grande variété de programmes gouvernementaux est ainsi prise en compte (allocations familiales, crédits d'impôts remboursables, etc.) en plus des impôts directs fédéraux et provinciaux. Les prestations d'assurance-emploi ne sont pas modélisées puisque le

⁸ Clavet, N.-J. and J.-Y. Duclos, May 2011. "Impact of child care support on female labor supply, family income and public finance", *CIRPÉE, Université Laval*
http://www.scb.se/Grupp/Produkter_Tjanster/Kurser/Dokument/IMA/NJ_Clavet_Paper.pdf, p. 1.

⁹ Kromann, L., August 2010. "Essays on Productivity and Labour Supply", University of Aarhus,
http://samfundsvidenskab.au.dk/fileadmin/site_files/filer_sam/dokumenter/subsites/phd/oekonomi/Dissertation/2006-/Lene_Kromann.pdf, p. ix.

modèle de micro-simulation est statique et que ces prestations sont de nature temporaire¹⁰.

4. *Quebec's 2008 Tax Reform: Impact on Social Well-being*

Paper's Abstract:

This paper presents the results of an assessment of the impact that a tax reform which involves raising the tax bracket thresholds in Quebec, Canada, has on the well-being of women living alone. Taxation rates are adjusted internally by maintaining constant tax revenues. To conduct this simulation, we use the Survey of Labour and Income Dynamics (SLID) and the Social Policy Simulation Database and Model (SPSD/M). The Canadian Tax and Credit Simulator (CTaCS) application is used to model each person's budget constraint. The behaviour of women is simulated with a discrete choice labour supply model (a translog utility function) that includes fixed costs. The model is estimated with a mixed logit¹¹.

Results:

The results point to a slight overall increase in hours worked following the simulated reform. However, the reform has a negative impact on hours worked for one woman in three and no impact for one woman in five. Following estimation of the labour supply function, the individual expenditure function is incorporated into social well-being indicators such as the Gini coefficient and the Atkinson index¹².

5. *Do Child Tax Benefits affect the Wellbeing of Children? Evidence from Canadian Child Benefit Expansions*

Paper's Abstract:

A vast literature has examined the impact of family income on the health and development outcomes of children. One channel through which increased income may operate is an improvement in a family's ability to provide food, shelter, clothing, books, and other expenditure-related inputs to a child's development. In addition to this channel, many scholars have investigated the relationship between income and the psychological wellbeing of the family. By reducing stress and conflict, more income helps to foster an environment more conducive to healthy child development. In this paper, we exploit changes in child benefits in Canada to study these questions. Importantly, our approach allows us to make stronger causal inferences than has been possible with the existing, mostly correlational, evidence. Using variation in child benefits across province, time, and family type, we study outcomes spanning test scores, mental health, physical health, and deprivation measures¹³.

¹⁰ Clavet, N.-J. J.-Y. Duclos and G. Lacroix, 2009. « Évaluation de l'Avis du CCLP – Rapport remis à la Direction générale adjointe de la recherche de l'évaluation et de la statistique », CIRPÉE, Université Laval,

<http://worthwhile.typepad.com/Rapport-CCLP-Final.pdf>, p. 9-10.

¹¹ Clavet, N.-J. J.-Y. Duclos, G. Lacroix, B. Fortin et S. Bibi, "Quebec's 2008 Tax Reform: Impact on Social Well-being", *International Microsimulation Association 2009, Abstracts – Session 1B*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1b-eng.htm>.

¹² *Idem*.

¹³ Milligan, K. and M. Stabile, December 2008. "Do Child Tax Benefits affect the Wellbeing of Children? Evidence from Canadian Child Benefit Expansions", *National Bureau of Economic Research working Paper Series*, <http://www.nber.org/papers/w14624.pdf>.

Results:

The findings suggest that child benefit programs in Canada had significant positive effects on test scores, as has been featured in the existing literature. However, we also find that several measures of both child and maternal mental health and well-being show marked improvement with higher child benefits. We find strong and interesting differences in the effects of benefits by sex of the child: benefits have stronger effects on educational outcomes and physical health for boys, and on mental health outcomes for girls. Our findings also provide some support for the hypothesis that income transfers operate through measures of family emotional well-being¹⁴.

¹⁴ *Idem.*

Chapter 3: Demosim

Designer: Statistics Canada, 2006

Description:

Demosim is a microsimulation model designed for population projections. The microsimulation technique allows a large number of characteristics of the population to be projected while also taking into account differentials in demographic behaviours from one sub-group of the population to another. Demosim has recently been used to project the ethnocultural diversity of the Canadian population from 2006 to 2031 with regard to visible minority group, generation status, religious denomination, mother tongue and place of birth. Other variables are also available such as highest level of schooling and participation in the labour force. The base population for Demosim is the 20% sample file of the Canadian Census. Multiple scenarios of future evolution in components of population growth are built to generate population projections¹⁵.

Users:

- Caron Malenfant, Éric (Demosim Team, Statistics Canada)
- Carrillo G., Ivan A. (Statistics Canada)
- Lebel, André (Demosim Team, Statistics Canada)
- Martel, Laurent (Demosim Team, Statistics Canada)
- Mata, Fernando (Policy Research Group, Department of Canadian Heritage)
- Spielauer, Martin (Statistics Division, Statistics Canada)
- Milorad Kovacevic (Statistics Canada)

Applications:

1. *The increasing ethnocultural diversity among the Canadian-born population: results from DemoSim, a population projection model using micro-simulation*

Paper's Introduction:

In recent decades, the ethnocultural diversity of the Canadian population has increased under the effect of sustained immigration levels from non-European countries. The proportion of persons belonging to visible minority groups¹, of non-Christian religions or of mother tongue neither English nor French has risen, especially in large urban centres such as Toronto, Montreal and Vancouver. Ethnocultural diversity first increased rapidly among the foreignborn population of Canada and it is now increasing rapidly among the second generation of Canadians, that is persons born in Canada with at least one parent born outside the country, as well as in the third (or more) generation, that is people born in Canada with both parents born in Canada. Based upon projections using a unique micro-simulation

¹⁵Statistics Canada, "Demosim", *Publications – Microsimulation*, <http://www.statcan.gc.ca/microsimulation/demosim/demosim-eng.htm>.

model, this paper focuses on these changes, distinguishing different generations of Canadians and showing the complex ethno cultural mosaic of the Canadian population by 2031. The paper will be divided in two parts. The first part will give a general overview of Statistics Canada's population projection micro-simulation model. The second part will consist of a detailed analysis of the ethnocultural diversity among the Canadian-born population¹⁶.

2. *Religion Mix Growth in Canadian Cities: A Look at 2006-2031*

This paper focuses on the growth trajectories of religion mix ratios in selected census metropolitan areas of Canada between 2006 and 2031. The data was drawn from special tables of the microsimulation population projections carried out by Statistics Canada and released in March 2010. Religion mix ratios including Non Christian to Christian, No religion to Religion and group specific ones were examined. The analysis found that the Non Christian to Christian ratio will double between 2006 to 2031 (from 15 to 30 per 100) while the No religion to Religion ratio will remain stable at about 26 per100 by 2031. Non Christian to Christian ratios will be equal or higher than 45 per 100 in cities such as Toronto, Abbotsford and Vancouver by 2031. No religion to Religion ratios will continue to be higher than average in most in British Columbia and other Western cities compared to others in the rest of Canada. To summarize findings latent class growth modeling and discriminant analysis were undertaken to classify cities in terms of prototypical patterns of growth and pinpoint characteristics of cities associated with these growth patterns. Overall, findings suggest that greater intra-Christian and intra-Non Christian religious diversity will be seen across cities of various sizes and geographies and that they will coexist with the more secular pattern of the reporting No religion in the next two decades¹⁷.

3. *Persistence and change of the relative difference in educational attainment by ethnocultural group and gender in Canada*

Paper's Abstract:

This article presents analytical findings on the persistence and change of the relative difference in educational attainment by ethno-cultural group and gender in Canada. As these trends cannot be observed from a single data source, a modelling technique to integrate longitudinal data lacking ethno-cultural detail with cross-sectional Census data was developed. First- and second-generation immigrants and/or members of most visible minority groups on average reach higher educational levels than their Canadian-born peers not belonging to a visible minority. This study reveals that the relative educational differences between the studied groups are both important in extent and remarkably stable over birth cohorts. The research presented in this paper was conducted in the context of Statistics Canada's population projection microsimulation model Demosim. Demosim marks an important milestone in establishing microsimulation for official population projections. It reflects the demand for models which can go beyond age and sex, capturing

¹⁶ Lebel, A., É. Caron Malenfant and L. Martel, "The increasing ethnocultural diversity among the Canadian-born population: results from DemoSim, a population projection model using micro-simulation", *2010 PAA Conference, Texas*, <http://paa2010.princeton.edu/download.aspx?submissionId=101757>, p. 1.

¹⁷ Mata, F., "Religion Mix Growth in Canadian Cities: A Look at 2006-2031 Projections Data Policy Research Group", *August 9th 2010 Canadian Heritage*, <http://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=1018&context=wmc>.

geographical detail, ethnic diversity, educational attainment and other characteristics¹⁸.

4. *Projections of the Diversity of the Canadian Population 2006 to 2031*

Product information:

The goal of the document entitled Population projections of diversity in Canada, 2006-2031, is to describe the future composition of the Canadian population, using different scenarios of population growth. Computed using a microsimulation model named Demosim, the projections emphasize on characteristics such as place of birth, generation status, visible minority group, religious denomination and mother tongue¹⁹.

Projections of the diversity of the Canadian population, 2006 to 2031, were released on March 9th, 2010, through The Daily of Statistics Canada. [A detailed analytical report is available at no charge.](#)

Other products from Demosim will also be available in the forthcoming months. Projections of the Aboriginal population, 2006 to 2031, are currently being prepared. The Demosim model itself, as well as a technical report describing the functioning and content of the microsimulation model, are also planned to be made available from this web page at a later date.

For more information on the Demosim model, please contact demography@statcan.gc.ca.²⁰

5. *An Overview of DemoSim, Statistics Canada's Microsimulation Model for Demographic Projections*

Background:

Because of persistent low fertility and strong immigration, Canada's population has rapidly become more ethnoculturally diverse in recent decades. Thus, from one census to the next, there has been an increase in the proportion of persons born abroad, persons with neither English nor French (Canada's two official languages) as their mother tongue and persons belonging to visible minorities, to cite only a few examples. However, this diversification is not occurring at the same pace throughout the country: while it has been quite rapid in the largest urban centres, especially Toronto, Montréal and Vancouver, where most newcomers settle, it is thus far very modest elsewhere in Canada.

Because of the various public policy implications of these rapid changes in the composition of the Canadian population, a federal department responsible for multiculturalism policies (Canadian Heritage) commissioned Statistics Canada in 2004 to make regional projections of the population of visible minority groups, the major linguistic groups, immigrant status and religious denomination. These projections were produced up to 2017, the year of the hundred and fiftieth

¹⁸ Spielauer, M., 2010. "Persistence and change of the relative difference in educational attainment by ethnocultural group and gender in Canada", *Vienna Yearbook of Population Research 2010 (Vol.8)*, http://hw.oeaw.ac.at/0xc1aa500d_0x0024fc47.pdf, p. 261

¹⁹ Statistics Canada, 2010. *Projections of the Diversity of the Canadian Population*, <http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=91-551-x&lang=eng>.

²⁰ Statistics Canada, "Demosim", Op cit., <http://www.statcan.gc.ca/microsimulation/demosim/demosim-eng.htm>.

anniversary of the Canadian Confederation. The great number of variables to be projected led Statistics Canada's Demography Division to develop, in co-operation with the Modelling Division, a microsimulation model—originally called Popsim, now DemoSim4—to create these projections, since models based on aggregate data proved unsuitable for this type of undertaking. Programmed using the *Modgen* microsimulation language, the model led in 2005 to the publication of an analytical report⁵ that received broad media coverage and has since been widely used, especially by various federal departments.

The publication of the results of the 2006 Census, combined with the timeliness of immigration-related issues and the changes occurring in Canada's population, called for an update of the results published in 2005. Agreement on this was reached in 2008 by Statistics Canada, the Department of Canadian Heritage, Citizenship and Immigration Canada and the Department of Human Resources and Skills Development Canada. The work carried out since then by Statistics Canada, while solidly based on the first version of the model, is more than merely an update. It is also an opportunity to review methods, expand the content of the model (new variables are included and new events are modeled) and test the various components that will eventually lead to the release of projections on Canada's Aboriginal populations (North American Indians, Métis and Inuit)⁶. Also, the time horizon of the projections has been extended to 2031.

This paper has been designed to give a brief overview of DemoSim: its objectives, its content and its functioning. Since the model is currently being developed, it should be noted that some of its aspects presented here are preliminary. It should also be noted that this text is based on the model's existing documentation, and its content will be presented in greater detail in a technical report on the projections, to be published in 2010²¹.

6. *Estimation of relative risks for population projections using microsimulations*

Paper's Abstract :

In microsimulations for population projections one is often interested in estimating an event probability. A request for microsimulation flexibility leads to a twostep method in which estimated baserisks are adjusted by factors based on relative risks. The concepts of odds ratios and relative risks are contrasted under these settings. To calculate the relative risks, we want to set the whole population (i.e. population average) as the reference category. Besides the obvious risk ratio with the denominator being an average risk for the population, we examine some alternative ways of duplicating the population for estimation of relative risks²².

7. *Ethno-cultural diversity and educational attainment: The modeling of education in the Canadian DemoSim population projection model*

Paper's Abstract:

The Canadian DemoSim model marks an important milestone in establishing microsimulation for official population projections. It reflects the demand for models which can go beyond age and sex, capturing geographical detail, ethnic diversity, educational attainment and other characteristics. This paper presents analytical

²¹ Caron Malenfant, É., 2009. "An Overview of DemoSim, Statistics Canada's Microsimulation Model for Demographic Projections", *Text of the presentation of Conference of the International Microsimulation Association*, <http://www.statcan.gc.ca/microsimulation/pdf/demosim-overview-vuedensemble-eng.pdf>, p. 1-2.

²² Carrillo G., I. A. and M. Kovacevic, "Estimation of relative risks for population projections using microsimulations", *SSC Annual Meeting, June 2009 Proceedings of the Survey Methods Section*, http://www.ssc.ca/survey/documents/SSC2009_ICarrillo.pdf.

findings on trends in ethnic and gender differences in educational attainment and how these findings are translated into the modeling of education in DemoSim. First and second generation immigrants and/or members of most visible minority groups on average reach higher educational levels than their Canadian born peers not belonging to a visible minority. One of the challenges of the analysis lies in the reconciliation of Census data with retrospective event history survey data. This study reveals that the relative educational differences between the studied groups are both important in extent and remarkably stable over birth cohorts, thus enabling us to formulate well supported projection scenarios²³.

8. *Persistence and change of the relative difference in educational attainment by ethno-cultural group and gender*

Paper's Abstract:

Over the last several decades Canada has experienced a considerable educational expansion. With each successive birth cohort, the proportion of those graduating from high school and attaining post-secondary education has increased. While this upward trend can be observed for all ethno-cultural groups, the relative differences between groups turn out to be remarkably persistent over many decades.

This paper presents the analytical findings underlying the modeling of educational progression in Statistics Canada's population projection microsimulation model DemoSim. We differentiate between 16 ethno-cultural groups by visible minority and aboriginal status. These groups are further broken down by gender and place of birth. The differences in educational attainment between groups follow more complex historical patterns for immigrants compared to those born in Canada. Overall, however, the most noticeable finding is the high persistence over time of the relative differences in educational attainment between all studied groups, with no major changes having occurred over the past twenty years.

The modeling approach combines event-history models (based on retrospective educational biographies collected in the General Social Survey) with cross-sectional analyses of Census data. In the context of the DemoSim microsimulation model, accounting for the education differences found between the studied ethno-cultural groups allows us to capture important compositional effects in an increasingly diverse Canadian population and labour force²⁴.

²³ Spielauer, M., "Ethno-cultural diversity and educational attainment: The modeling of education in the Canadian DemoSim population projection model", *Paper presented at the 2009 Scio-Economic Conference of Statistics Canada, Ottawa, Canada – June 2009*, www.oeaw.ac.at/vid/educ/download/educ09_04_03.pdf.

²⁴ Spielauer, M., Mai 2009. "Persistence and change of the relative difference in educational attainment by ethno-cultural group and gender", *Paper presented at the 2009 Scio-Economic Conference of Statistics Canada, Gatineau, Canada*, www.spielauer.ca/SEC_EducPersist_Cover.doc.

Chapter 4: Dynacan

Designer: Statistics Canada

Description:

DYNACAN is a Canadian, stochastic (Monte Carlo), open, longitudinal, dynamic microsimulation model developed for generating longitudinal and cross-sectional, as well as fiscal and policy-oriented analyses of Canadian Social Security Schemes such as the Canada Pension Plan (CPP), the Old Age Security (OAS) Program and the Guaranteed Income Supplement (GIS). DYNACAN is validated in many respects, the main one being that its demographic and financial results are made consistent with those of the macrosimulation model ACTUCAN. ACTUCAN is the model used by the Chief Actuary for Canadian public pensions plans for purposes of the statutory actuarial valuations of the CPP and the OAS²⁵.

Users:

- Avery, Marvin (DYNACAN team)
- Bouffard, Neal (DYNACAN team)
- Easther, Richard (Strategic Forecasting inc.)
- Johnson, Tom (Strategic Forecasting inc.)
- Leblanc, Neal (DYNACAN team)
- Morrison, Richard J. (DYNACAN team)
- Petrovic, Vesna (DYNACAN team)
- Redway, Howard (PENSIM2 team)
- Vink, Jan (Strategic Forecasting inc.)

Applications:

1. *A Match Made In Silicon: Marriage Matching Algorithms for Dynamic Microsimulation*

Paper's Abstract:

Longitudinal dynamic microsimulation models generally implement marriage markets that process pools of prospective marriage partners into sets of newly minted traditional marriages and common-law unions. The algorithms' success in creating realistic unions is critical to the models' demographics, and thus to their capacity to simulate outputs such as family structures, taxes, and survivor pensions. Consequently, it is useful to examine the algorithms used to create unions from sets of prospective partners, and assess those algorithms in terms of the realism of the distributions of the resulting unions. This paper assesses four different algorithms, including two that are currently in use in the Pensim2 and DYNACAN models, and

²⁵ Morrison, R., November 1998. *Overview of DYNACAN*, http://www.actuaries.org/CTTEES_SOCSEC/Documents/dynacan.pdf, p. 1.

two others under consideration as replacements for them. The analysis extends a set of measures previously used to assess the realism of prospective matches, and evaluates each of the matching algorithms with respect to them. A concluding section places the selection of an appropriate matching algorithm within the larger context of the formation and dissolution of traditional and common-law unions, and the evolution of the institution of marriage²⁶.

Paper's results:

New algorithms were designed and tested, and the results show that the stochastic algorithm described in Bouffard et al. (2001) generates marriages that best fit the census data *when operated in the current environment*. While the new algorithms appear to be promising and have desirable properties, the poor quality of the compatibility measure effectively hobbles them, thus preventing any true testing. As a result, we believe that it would be premature to claim that these results offer an accurate picture of the potential of the new algorithms. As a result, it seems clear that a better metric is required, however, the shifting social trends for marriage make such an improvement difficult to say the least. For this reason, we believe that microsimulation models need to look at marriage in a broader context, and model the more "modern" relationships, especially cohabitation and common-law²⁷.

2. *Spending Down One's Retirement Assets in an Uncertain World*

Paper's Abstract:

Increasingly, individuals retire with stocks of assets that are expected to provide them with significant portions of their lifetime retirement incomes. Trends such as shifts from defined benefit plans to defined contribution plans, and declining pension coverage are increasing individuals' responsibility for managing the financial component of their retirements. Moreover, this management takes place in an uncertain world, with major risks that include indeterminate life spans and returns to assets, as well as inflation risks. Further, that management takes place in a complex environment of tax obligations and benefit programs that are income-tested. Advice on how one should spend down one's retirement assets is often simplistic, and those providing the advice may be subject to considerable self-interest. This paper reports on a preliminary attempt to use microsimulation to address the issue of asset drawdown. For each of a selection of commonly proposed drawdown strategies, it simulates large numbers of independent life courses for an illustrative individual. From these, it describes the resulting distributions of discounted lifetime consumption and its variability, taxes paid and government benefits received, and the value of estates remaining unspent at death. The analysis shows substantial differences across the traditionally proposed strategies. Although the analysis uses a single individual for its illustration, the technique generalizes to other assumptions, other tax/benefit systems, including those of other countries, the inclusion of employer pensions, and considerably more complex drawdown strategies²⁸.

²⁶ Leblanc, N., R. Morrison and H. Redway, 2010. *A Match Made In Silicon: Marriage Matching Algorithms for Dynamic Microsimulation*, http://www.microsimulation.org/IMA/Ottawa_2009/Papers/Leblanc.%20Neal.pdf, p. 1

²⁷ *Ibid.*, p. 26.

²⁸ Avery, M. and R. Morrison, "Spending Down One's Retirement Assets in an Uncertain World", *Abstracts - Sessions 2d, International Microsimulation organization 2009*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session2d-eng.htm#a12>.

3. *High-Level Design Overview of DYNACAN*

Paper's Abstract:

The paper gives a high-level overview of DYNACAN, a Canadian Longitudinal Microsimulation Model. It presents DYNACAN's major components, as well as utilities that are available to facilitate simulation, debugging and validation.

DYNACAN is a model built and used for the longitudinal simulation of Canadian population and the calculation of Canada Pension Plan (CPP) contributions and benefits. Its primary purpose is to evaluate hypothetical or proposed changes to CPP legislation.

DYNACAN has four components:

- DYNACAN-A (module for setting up the starting population database, based on the 1971 Canadian Census data)
- DYNACAN-B (module for longitudinal simulation of Canadian demographics and earnings)
- DYNACAN-C (module for calculating CPP contributions and benefits)
- DYNACAN-D (module for generating marginal tax rate projections).

In addition to the model itself, which is written in C/C++ and runs on Linux, we also use a set of SAS scripts for generating exhaustive and detailed cross-sectional and longitudinal results in tabular and graphical format, as well as Java-based results browser.

The paper mainly focuses on DYNACAN-B and DYNACAN-C structure, input and output, but it also gives a brief overview of the other DYNACAN components, with examples and a trace of a family through all the components of our model²⁹.

4. *Rates of Return in the Canada Pension Plan: Sub-populations of Special Policy Interest*

Paper's Abstract:

Evaluations of public pension programs may include calculations for the internal rates of return those programs provide. For example, rate of return calculations are a standard component of the legislatively mandated, statutory actuarial reports for the Canada Pension Plan. These cohort-specific rates help to demonstrate the value of the Plan for past, present, and future cohorts of Plan participants. The DYNACAN longitudinal microsimulation model already permits the generation of rates of return that lie close to the values published by the Chief Actuary, and further enables the calculation of gender-specific rates. This paper extends earlier DYNACAN rate of return calculations to sub-populations other than gender. It presents and interprets cohort-specific rates of return for several sub-populations of policy interest, including ever-married persons, early retirees, and disability beneficiaries. The paper describes the use of the DYNACAN model to generate the underlying demographic, earnings, contribution, and benefit histories, and notes some of the practical issues associated with deriving the internal rates of return³⁰.

²⁹ Petrovic, V., "High-Level Design Overview of DYNACAN", *Poster Session, International Microsimulation organization 2009*, <http://www.statcan.gc.ca/conferences/ima-aim2009/poster-session-affiche-eng.htm#a15>.

³⁰ Morrison, R.J., June 2007. *Rates of Return in the Canada Pension Plan: Sub-populations of Special Policy Interest*, www.euro.centre.org/ima2007/programme/papers/Morrison2_abs.doc.

5. *Matchmaker, Matchmaker, Make Me a Match*

Paper's Abstract:

Effective marriage matching, i.e. forming specific couples from pools of potential marriage partners, is vital for the success of dynamic longitudinal microsimulation models. This paper identifies some problems with a deterministic algorithm previously used in CORSIM, and in its “child” models, e.g., DYNACAN and POLISIM, for matching prospective marriage partners. It describes an alternative, stochastic, algorithm that provides somewhat better results. A set of validation measures illustrates the extent of this improvement, and indicates something of the ample room remaining for additional improvement. The paper situates the choice of a matching algorithm within the broader arena of marriage markets, and identifies some other areas in which improvements are desirable³¹.

Paper's conclusion:

Even considering the caveats just noted, based on the analyses noted here, and others, both the CORSIM and DYNACAN model teams have adopted the stochastic matching algorithm for their models. The teams see this adoption as an interim step in an ongoing effort to improve the quality of the overall marriage module. We hope that improvements to other portions of the broader marriage module, especially a re-estimation of the function for the compatibility index, will improve the fit between actual and synthesized marriages still further³².

³¹ Bouffard, N., R. Easter, T. Johnson, R. J. Morrison and J. Vink, September 2001. *Matchmaker, Matchmaker, Make Me a Match*, http://www.microsimulation.org/IMA/BEJE/BEJE_4_2_4.pdf, p. 2.

³² *Ibid.*, p. 20.

Chapter 5: Lifepaths

Designer: Statistics Canada

Description:

LifePaths is a dynamic longitudinal microsimulation model of individuals and families. Using behavioural equations estimated using a variety of historical micro-data sources, LifePaths creates statistically representative samples consisting of complete lifetimes of individuals. The model's behavioural equations generate, at sub-annual resolution, the discrete events that together constitute an individual's life history. In addition to its longitudinal capabilities, a complete set of overlapping cohorts allow LifePaths to produce accurate and representative cross-sectional results from the year 1971 onwards.

LifePaths is used to analyze, develop, and cost government programs that have an essential longitudinal component, in particular those whose nature requires evaluation at the individual or family level. It can also be used to analyze a variety of societal issues of a longitudinal nature such as intergenerational equity or time allocation over entire lifetimes³³.

Users:

- Boothby, Daniel
- Carrière, Yves (Statistics Canada)
- Charbonneau, Patrick (Statistics Canada)
- Cahill, I. (Statistics Canada)
- Chen, E. (Statistics Canada)
- C. Wolfson, Michael (Statistics Canada)
- Décarie, Yann (INRS)
- Denhez, Alain (Senior Director, PSI)
- Dosman, Donna (Statistics Canada)
- Fast, Janet (University of Alberta)
- Gaymu, Joëlle (INED)
- Gribble, Steve (Statistics Canada)
- Keefe, Janice (Mount Saint-Vincent University)
- Légaré Jacques (Université de Montréal)
- Lin, Xiaofen (Statistics Canada)
- Martel, Laurent (Statistics Canada)
- Moore, Kevin (Statistics Canada)
- Nguyen, Huan (Socio-Economic Analysis and Modeling Division Analysis and Development Branch Statistics Canada)
- Plager, Laurie (Statistics Canada)
- Rajbhandary, Sameer (Public Health Agency of Canada)

³³ Statistics Canada, "Lifepaths", *Publications : Microsimulation*, <http://www.statcan.gc.ca/microsimulation/lifepaths/lifepaths-eng.htm>

- Rowe, Geoff (Socio-Economic Analysis and Modeling Division Analysis and Development Branch Statistics Canada)
- Spielauer, Martin (Statistics Canada)
- Yoshino, Satomi (University of Alberta)

Applications:

1. *House ownership and equity in the Canadian LifePaths model*

Paper's Abstract:

This paper discusses how home equity was incorporated into Statistics Canada's LifePaths microsimulation model. Home equity was incorporated to improve analysis of retirement income adequacy for Canadians. For a majority of Canadians home equity is their single largest investment. It therefore cannot be ignored when analyzing sources of retirement income. Home equity may also be of interest when studying broader issues such as savings and wealth for the general population. LifePaths simulates home equity over the entire life course of each simulated individual. The behavioural and home valuation assumptions were derived from a number of micro-data sources, including property tax data, personal income tax data, a number of censuses, and the Survey of Financial Security. In the model, home equity is affected by relevant events such as marriage, divorce, retirement, and death of a spouse. Finally, results are presented that show the impact of home equity on measures of retirement income adequacy³⁴.

2. *Accounting for the Intergenerational Transmission of Educational Attainment: The Modeling of Education in the Canadian LifePaths Microsimulation Model*

Paper's Abstract:

Parents' education is one of the strongest predictors of individual educational choices and careers. The new education modules of Statistic Canada's microsimulation model LifePaths recognize the importance of intergenerational transmission. LifePaths thus provides a powerful tool to study its effects, as education constitutes one of the key explanatory variables in various behavioural domains including fertility, partnership formation, labour market participation, and income. This paper presents analytical findings on the degree and persistence of the influence of parental and family characteristics on educational choices in Canada and the implementation of intergenerational transmission of education in LifePaths. The recent educational expansion in Canada can partly be attributed to the changing educational composition of the parents' generation, thus representing a composition effect rather than a change of behaviour at the individual level. While these findings can improve projections by more informed scenarios on future trends, LifePaths is also well suited to address the policy dimensions and socio-economic consequences of this type of inequality³⁵.

³⁴ Spielauer, M., 2011. "House ownership and equity in the Canadian LifePaths model", *International Microsimulation Conference (IMA) Stockholm – Papers*, <http://www.spielauer.ca/>.

³⁵ Spielauer, M., "Accounting for the Intergenerational Transmission of Educational Attainment: The Modeling of Education in the Canadian LifePaths Microsimulation Model", *International Microsimulation Conference (IMA) Stockholm – Papers*, <http://www.spielauer.ca/>.

3. *Projecting the cost of the care-giving experience using LifePaths*

Paper's Abstract:

Population aging has several implications for the demand for and supply of care services, and for the health and well-being of receivers and providers of care. Much of the support received comes from informal support networks of spouse, children and friends. Although these supports are critical, there are many long-term repercussions for caregivers who must sometimes reduce their hours of paid work part-time or temporarily leave their jobs to meet care demands. In this project we add a new module to the LifePaths microsimulation model to project caregivers' full lifetime economic consequences resulting from care-giving episodes, including lost wages and pension benefits. Our statistical analysis is based on the General Social Survey which allows us to model the risk of becoming a caregiver and subsequent labour market decisions as a function of given personal, family and labour market characteristics³⁶.

4. *Comparing lifetime redistributive properties of Canadian tax and transfer regimes across years using LifePaths*

Overview :

The redistributive properties of tax and transfer legislative regimes can be compared across years by using a static microsimulation model and a fixed reference population. This paper illustrates how such analyses can be extended to compare the lifetime redistributive properties of tax and transfer regimes across years. First, a longitudinal microsimulation model is used to construct an artificial reference 'cross-sectional' cohort of individuals that, at each age, experience the socio-economic conditions and demographic experience of a given reference year. Next, this artificial reference cohort is simulated longitudinally using the tax and transfer regimes of selected years of interest. Finally, the lifetime redistributive properties of the tax and transfer regimes of those chosen years are compared. Using this technique and the LifePaths microsimulation model, the evolution of the lifetime redistributive properties of the Canadian tax and transfer system over the past 25 years is presented³⁷.

5. *Using dynamic microsimulation models to face the policy issue of caring for the most vulnerable elderly: a comparison of Canada with some European countries*

Overview :

In developed countries, population aging is a well known reality. The proportion of elderly in our societies is increasing, most of them being in good health. However, some others are in a vulnerable situation. In fact, among those aged 75 and over, elderly in poor health and without a spouse and any surviving children are the most

³⁶ Décarie, Y., M. Spielauer, D. Dosman, J. Fast and S. Yoshino, 2011. "Projecting the cost of the care-giving experience using LifePaths", *International Microsimulation Conference (IMA) Stockholm – Papers*, <http://www.spielauer.ca/>.

³⁷ Gribble, S. and L. Plager, "Comparing lifetime redistributive properties of Canadian tax and transfer regimes across years using LifePaths", *Statistics Canada, Abstracts - Sessions 3I, International Microsimulation organization 2009*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session3i-eng.htm#a61>.

vulnerable. Most of them live alone. No doubt, these elderly will require formal care, while being at the same time at a high risk of institutionalisation. Moreover, this group of persons is growing quickly and unevenly by gender. The purpose of this paper is to foresee how many people will find themselves in such situation according to different health scenarios. For example, the most optimistic scenario assume that the increment in life expectancy will be all years in good health, meaning that only Disability Free Life Expectancy (DFLE) will be increasing. Thus, we present data up to 2030 for Canada. These data come from a global dynamic microsimulation model developed by Statistics Canada and named LifePaths. We also present data for some European countries coming from a dynamic household microsimulation model named LIPRO (Lifestyle PROjections). Both of these microsimulation models are based on the methodology of multistate demography. Results show that even in the most favourable health scenario, the numbers of these vulnerable individuals will increase sharply. Policy makers should be aware of this inevitable situation and ready to act accordingly³⁸.

6. *Lifetime income inequality*³⁹

Presented at the IPAC Conference, Québec, August 2008.

7. *Projecting the Future Availability of the Informal Support Network of the Elderly Population and Assessing Its Impact on Home Care Services*

Paper's Introduction:

The main objective of this research is to project the future availability of informal support network to meet the need for assistance in performing everyday activities among the disabled elderly population for the period 2001 to 2031. Data from two national surveys, the 1996 National Population Health Survey (NPHS) and the 1996 General Social Survey (GSS), are used to identify factors associated with disability and sources of assistance among the elderly population. These results were entered into Statistics Canada's LifePaths microsimulation model to project the use of informal and formal networks in the future⁴⁰.

Results Overview:

The results show that for the period 2001 to 2031, the average annual growth rate of the number of disabled elderly needing assistance could be about 2.5%. However, the sensitivity analysis shows that an improvement in the health of the population could reduce in a non negligible way this growth rate. The results also show that, all things being equal, a greater proportion of elderly persons living with a spouse

³⁸ Décarie, Y., J. Légaré, P. Charbonneau, J. Keefe, J. Gaymu and the FELICIE team, 2009, "Using dynamic microsimulation models to face the policy issue of caring for the most vulnerable elderly: a comparison of Canada with some European countries Statistics Canada", *Abstracts - Sessions 1B, International Microsimulation organization 2009*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1b-eng.htm#a28>.

³⁹ Denhez, A., "Lifetime income Inequality", PRI, IPAC Congerence, Québec, August 2008, PDF, <http://www.ipac.ca/2008/docs/presentation/2608AM-atelier4-Denhez.pdf>. NO ABSTRACT AVAILABLE.

⁴⁰ Carrière, Y., J. Keefe, J. Légaré, X. Lin, G. Rowe, L. Martel and S. Rajbhandary, 2008. "Projecting the Future Availability of the Informal Support Network of the Elderly Population and Assessing Its Impact on Home Care Services", *Demography Division of Statistics Canada*, <http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=91F0015MIE2008009&lang=eng>, p. 1.

would relieve some of the pressure on the formal network. This positive effect could be dampened in part when joint survivorship is also meaning joint disability⁴¹.

8. *Using Statistics Canada LifePaths Microsimulation Model to Project the Health Status of Canadian Elderly*

Paper's Abstract :

Complex population projections usually use microsimulation models; in Canada, Statistics Canada has developed a global dynamic microsimulation model named LifePaths in the Modgen programming language to be used in policy research. LifePaths provides a platform to build on for our research program, conjointly with Dr Janice Keefe from Mount Saint Vincent University, on projections of the Canadian chronic homecare needs for the elderly up to 2031 and of the human resources required. Beside marital status, family networks and living arrangements, future health status of the elderly is a key variable, but an intricate one. Since health status transitions were previously conditioned only on age and sex, we will use here the current disability module of LifePaths with longitudinal data from Canada's National Population Health Survey (NPHS). These new health status transitions are considering other significant explicative variables like marital status, education etc. We will then present projections of future Canadian elderly by health status and a comparison with nine European countries for the Future Elderly Living Conditions in Europe (FELICIE) Research Program which has used the same approach. Our previous researches have shown the importance of future disability level for the management of an elderly society. The main output of the present paper would first produce, with new health scenarios, new estimates for Canada of elderly in poor health, for those aged 75 and over. Secondly, it would produce an interesting comparative analysis, useful especially for implementing new policies for the well-being of the Canadian elderly⁴².

Paper's Conclusion:

Simulating the Canadian population with an optimistic disability scenario largely reduce the number of Canadian elderly aged 75 years and over in poor health. In 2031, we should find approximately 20% less people in poor health in the healthy scenario than in the base scenario. Moreover, the base scenario predicts a small expansion of disability due to the internal changes occurring in the characteristics of the Canadian population and that are taken into account by LifePaths. Consequently, the differences between the number of Canadian elderly in poor health and those observed in FELICIE countries are larger than expected because their constant scenario keeps their disabled people in the population at the same proportion throughout the period.

Furthermore, up to 2015, the relative increase in the Canadian and in the FELICIE countries total population (all health status) and people in poor health aged 75 years and over is similar. Afterwards, the impact of the larger baby-boom that occurred in Canada differentiates considerably the latter from FELICIE countries in terms of total population (all health status) and people in poor health. Indeed, both the total population aged 75 and over and the sub-population in poor health are expected to grow more rapidly in Canada than in Europe. Concerning the total populations, the difference between Canada and Europe is larger in the healthy scenario because both

⁴¹ *Idem.*

⁴² Légaré, J. and Y. Décarie, January 2008. "Using Statistics Canada LifePaths Microsimulation Model to Project the Health Status of Canadian Elderly", *SEDAP Research Paper No. 227*, <http://ideas.repec.org/p/mcm/sedapp/227.html>, p. 2.

disability and mortality levels are linked together in the Canadian microsimulation model.

Finally, one must keep in mind that reaching the age of 75 corresponds to the beginning of a frailty period, implying increased needs for specific care. The rapid growth of our projected Canadian elderly population should raise the awareness of Canadian policy makers about the issues on future homecare needs and homecare services. Thus, tomorrow's problems can be avoided by today's actions⁴³.

9. *Simulating Employment Careers in the LifePaths Model: Validation across Multiple Time Scales*

Paper's Abstract :

LifePaths has embarked on a multi-year project to examine issues relating to income levels and income adequacy among Canada's seniors – both in the present and out into the foreseeable future. In its initial stage, the project is focussing on extensive validation to build consensus among users as to the reliability of the model and its projections.

In this report, we consider the validity of LifePaths simulations of employment careers by examining aspects of the simulations at different time scales: sub-annual, annual, and multi-decade time intervals. The validity of LifePaths simulations is established by comparisons between simulation output and direct observations for specific periods in calendar time.

A problem common to both the estimation and the validation stages in the development of our model of employment careers is the lack of any integrated data source on employment dynamics at all time scales. LifePaths' employment module is based on a rich and unusually extensive, core longitudinal dataset that accounts for the dynamics of distinct employment spells. But, because of its sample design, that dataset can not directly display dynamics at either the annual time scale (e.g., complete seasonal work patterns) or the career time scale. (i.e., evolving multi-decade work patterns). In that regard, LifePaths' greatest value may be that it can serve as the vehicle for integration of existing, fragmentary data that will allow credible simulations and projections of complete employment careers, earnings trajectories, saving patterns, and, ultimately retirement income streams⁴⁴.

10. *Retirement Incomes Past, Present, and Future: Using LifePaths to Evaluate Earnings Replacement after Retirement*

Overview:

In Canada, much of the public policy discourse and analysis on the subject of retirement income has focused on issues relating to the public provision of a minimum income floor for seniors, i.e., poverty avoidance. The Canadian retirement income system (RIS) is often considered an impressive policy success by this standard.

⁴³ *Ibid.*, p. 18.

⁴⁴ Rowe, G., H. Nguyen, and K. Moore, 2007. "Simulating Employment Careers in the LifePaths Model: Validation across Multiple Time Scales", *Socio-economic Analysis and Modeling division Statistics Canada*, <http://www.docstoc.com/docs/81613703/Simulating-Employment-Careers-in-the-LifePaths-Model>.

Considerably less analytic attention has been paid to success of the RIS in achieving the other stated goal of Canadian retirement income policy – that Canadians avoid a significant decline in their standard of living after retirement. One crucial aspect of this is the extent to which earnings are replaced with other sources of income. An assessment of this requires information on individuals' pre-retirement earnings, as well as their subsequent income after retirement.

LifePaths, a Canadian dynamic microsimulation model, models individual life-courses from birth to death, including earnings. As a result of recent enhancements, LifePaths now supports the modeling of all the major sources of income that Canadians receive in retirement: public pensions, private pensions, registered retirements savings plan income, and non-registered investment income. The income tax system, including various provisions relating particularly to seniors and retirement income, is also modeled.

This study uses LifePaths to explore the extent to which the earnings of Canadians are replaced by other sources of income after retirement, both before and after taxes. Simulated earnings replacement rates are analyzed for the past, present, and future in order to examine the evolution and maturation of the RIS and its various components⁴⁵.

11. *Convergence of Male and Female Patterns of Employment Activity*

Paper's Abstract:

The steady convergence of men and women's employment/population ratios has been one of the most dramatic changes observed in the Canadian labour market over, at least, the past 25 years. Indeed, it is probable that, within the population as a whole, gender differences in work behaviour are now substantially less important than differences in skill levels. Nevertheless, there may be persistent differences in the dynamics of employment activity between men and women; for example, differences that are more apparent in relation to job tenure and job transitions. We will try to reconcile the evidence favouring continued convergence with evidence of persistent differences, in order to motivate a range of projection scenarios for Canada's labour market. In our examination of men and women's employment dynamics, we make use of data from the Canadian Labour Force Survey (LFS) on transitions among the labour market states: *self-employed*, *paid employee* and *not employed*. The LFS was not designed to be a longitudinal survey. However, given that respondent households typically remain in the sample for six consecutive months, it is possible to reconstruct sixmonth fragments of longitudinal data from the monthly records of household members. Such longitudinal micro-data – altogether consisting of millions of person-months of individual and family level data – is useful for analyses of monthly labour market dynamics over relatively long periods of time, 25 years and more⁴⁶.

⁴⁵ Moore, K., "Retirement Incomes Past, Present, and Future: Using LifePaths to Evaluate Earnings Replacement after Retirement", *Abstracts - Sessions 3H, International Microsimulation organization 2009*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session3h-eng.htm#a35>.

⁴⁶ Rowe, G. and H. Nguyen, 2004. "Convergence of Male and Female Patterns of Employment Activity", *Socio-Economic Analysis and Modeling Division Analysis and Development Branch, Statistics Canada*, <http://www.statcan.gc.ca/pub/11f0024m/pdf/papers-etudes/4224998-eng.pdf>, p. 1.

12. *The Homing Instinct: Aspects of Family Return Migration from Census Data*

Paper's Abstract:

In this paper, we provide results of analysis of 1996 Census data on province-of-residence at census time as well as one-year ago, five-years ago and at birth. Taken as a whole, our analysis of these data formed the basis for the inter-provincial migration module of Statistics Canada's LifePaths microsimulation model². Here we will focus on some distinctive features of the family (married husband-wife) migration sub-component. Family migration propensities are of interest because families are a decision-making unit that can exhibit complex behaviour. Compared with unattached individuals, couples may be less likely to leave their place of birth and more likely to return. In this study, we will examine return migration emphasizing two complicating aspects of the process: that 'returns' can be identified either with the province-of birth or with another previous province-of-residence, and that spouses may differ which moves would constitute a return. To control for age, education and other factors in our comparisons of migration propensities, we estimate a system of competing risks, proportional hazard equations. This system of competing-risk equations comprises 11 alternative destinations for each province of origin utilizing an exogenously determined, period-specific, baseline hazard for each origindestination pair⁴⁷.

Paper's Results:

Perhaps the best way of summarizing these results is that they indicate that migration decisions, particularly of families, have a strongly idiosyncratic component. This is particularly so, in as much as differences in migration histories between spouses can lead to large differences in migration propensities (Table 1). And, in general, the extreme range of migration behaviour that was implied in Figure 2 has not been accounted for by the control variables introduced in the hazard equations. One indication of the idiosyncrasy of migration choices is the evidence that the place where spouses may have lived in the past can have a determining influence on where they may choose to live in the future. (That influence may over-ride the objective attractions of alternative destinations.) Another indication of idiosyncrasy is the implied intra-family negotiation that might give rise to differing migration propensities of joint return migration as opposed to return for only one spouse, etc. These results are consistent with a social capital perspective: granting that social capital may not be traded; but may be inherited, acquired by marriage or formed by one's own efforts⁴⁸.

13. *Benchmarking parameter estimates in logit models of binary choice and semiparametric survival models*

Paper's Abstract:

An approach to exploiting the data from multiple surveys and epochs by benchmarking the parameter estimates of logit models of binary choice and semiparametric survival models is developed. The goal is to exploit the relatively rich source of socioeconomic covariates offered by Statistics Canada's Survey of Labour and Income Dynamics (SLID), and also the historical timespan of the Labour Force Survey (LFS), enhanced by following individuals through each interview in

⁴⁷ Lin, X. and Rowe, G., "The Homing Instinct: Aspects of Family Return Migration from Census Data", *Canadian Population Society Annual Meeting, Dalhousie University, Halifax* (2003), http://web.uvic.ca/~canpop/2003/lin_rowe.pdf, p. 1.

⁴⁸ *Ibid.*, p. 13.

their sixmonth rotation. A demonstration of how the method can be applied is given, using the maternity leave module of the LifePaths dynamic microsimulation project at Statistics Canada. The choice of maternity leave over job separation is specified as a binary logit model, while the duration of leave is specified as a semiparametric proportional hazards survival model with covariates together with a baseline hazard permitted to change each month. Both models are initially estimated by maximum likelihood from pooled SLID data on maternity leaves beginning in the period 1993–1996, then benchmarked to annual estimates from the LFS 1976–1992. In the case of the logit model, the linear predictor is adjusted by a logodds estimate from the LFS. For the survival model, a KaplanMeier estimator of the hazard function from the LFS is used to adjust the predicted hazard in the semiparametric model⁴⁹.

Paper's Conclusions:

The technique that we have developed appears to be quite successful in benchmarking of the logit and survival model parameters so that the essential features of the LFS data are captured in LifePaths predictions. The key to benchmarking the logit model is the adjustment of the parameter corresponding to the “constant term” in the linear predictor that is imbedded in the logistic distribution function in order to predict the conditional expectation of the dependent variable. Section 3.1 develops the technique in a general framework that includes other models of binary choice. Particularly, it would extend to the popular probit model where a linear predictor is embedded in the standard normal distribution function. Benchmarking of the semiparametric survival model hinges on the adjustment of all the parameters representing the baseline hazard. Our results illustrate how the entire shape of the distribution of durations predicted by the model can be made to evolve through time according to a pattern revealed by supplementary data⁵⁰.

14. Longitudinal Analysis of Labour Force Survey Data

Paper's Abstract:

The Labour Force Survey (LFS) was not designed to be a longitudinal survey. However, given that respondent households typically remain in the sample for six consecutive months, it is possible to reconstruct 6-month fragments of longitudinal data from the monthly records of household members. Such longitudinal data – altogether consisting of millions of person months of individual and family level data – is useful for analyses of monthly labour market dynamics over relatively long periods of time, 25 years and more.

We make use of these data to estimate hazard functions describing transitions among the labour market states: selfemployed, paid employee and not employed. Data on job tenure, for the employed, and on the date last worked, for the not employed – together with the date of survey responses – permit the estimated models to include terms reflecting seasonality and macro-economic cycles as well as the duration dependence of each type of transition. In addition, the LFS data permits spouse labour market activity and family composition variables to be included in the hazard models as timevarying covariates. The estimated hazard equations have been incorporated in the LifePaths microsimulation model. In that setting, the equations have been used to simulate lifetime employment activity from past, present and

⁴⁹ Cahill, I, and E. Chen, "Benchmarking parameter estimates in logit models of binary choice and semiparametric survival models", *Survey Methodology*, 28(1), (2002), <http://www.statcan.gc.ca/ads-annonces/12-001-x/6417-eng.pdf>, p. 51.

⁵⁰ *Ibid.*, p. 60

future birth cohorts. Simulation results have been validated by comparisons with LFS age profiles of employment/population ratios from the period 1976 to 2001⁵¹.

Paper's conclusions :

We have demonstrated that the LFS data – when organized into the fragmentary event histories collected over the six-month periods that most respondents spend in the sample – represents a significant longitudinal data asset. There is sufficient sample and breadth of content to provide for important analysis of labour market dynamics and, conceivably, of demographic processes such as fertility. Moreover, the data is monthly and spans more than a quarter century, so that analysis based on it has uninterrupted time depth that is unique in Canada. Much remains to be done. Future work will involve extending and refining our models. In addition, we need to make further progress in variance estimation. So far, we have only preliminary estimates of the design effects on the variances of coefficients in our hazard equation (i.e., in the range of 1.1 to 1.2). To date, with this line of research still in its initial stages, our approach to inference has been informal⁵².

15. *Rate of Return to Education: A Distributional Analysis Using the LifePaths Model*

Paper's Abstract:

This paper reports estimates of the distribution of individual private rates of return to undergraduate and community college education by field of study for Canada. It is important to know the dispersion of the private rate of return to post-secondary education, as well as its average level. There are very different implications for educational policy and for individual educational decisions if, for example, 40% of post-secondary graduates have negative private rates of return to their educational investment than if 10% have negative rates of return, whatever the mean level of the private rate of return. To our knowledge, there is no previous research reporting estimates of the distribution of individual private rates of return to education.

Individual rates of return were derived by comparing simulated lifetime earnings streams of pairs of individuals. Each pair was made up of a post-secondary graduate and a high school graduate 'clone'. The simulations were carried out using the LifePaths model of Statistics Canada.

Results Overview:

Our principal finding is that there is a very wide range of outcomes, as measured by individual rates of return, within each level of study and within fields of study. The range of individual rates of return within fields of study was much wider than the range of median rates of return among fields of study within a level of study, although fields of study varied greatly in their median rates of return. The variability in rates of return was greater at the community college level than at the university undergraduate level.

Median rates of return to the bachelor's degree were 12% for men and 13% for women; for community college diplomas the median rates of return were 16% for men and 18% for women. Twenty percent of bachelor's degree graduates and thirty percent of community college graduates had negative rates of return to their

⁵¹ Rowe, G, and H. Nguyen, 2002. "Longitudinal Analysis of Labour Force Survey Data", *Symposium on Modeling Survey Data for Social and Economic Research*, Statistics Canada, Ottawa, <http://www.statcan.gc.ca/pub/11-522-x/2002001/session9/6739-eng.pdf>. p. 1.

⁵² *Ibid.*, p. 9.

investment in post-secondary education. Median rates of return by field of study and gender ranged from 5% to 23% at the undergraduate level and from 0% to 20% at the community college level. In fields of study where male and female graduates could be compared, women had higher rates of return to post-secondary education, but lower lifetime earnings.

We also compared distributions of lifetime earnings for male and female post-secondary and high school graduates. Median lifetime earnings for female and male graduates with post-secondary degrees are greater than lifetime earnings at the 75th percentile for female and male high school graduates⁵³.

16. *Perspectives on Working Time over the Life Cycle*

Overview:

In “Perspectives on Working Time over the Life Cycle,” Michael Wolfson and Geoff Rowe utilize a new longitudinal microsimulation model developed by Statistics Canada—the LifePaths model—to examine statistical patterns of working time over the life cycle. Life-Paths provides a means for blending data on both cross-sectional timeuse patterns and longitudinal labor force dynamics. It can be used to produce multistate life tables that relax some of the restrictive assumptions that underlie conventional working life tables, and it can be used to conduct a wide range of policy-related analyses as well⁵⁴.

Results overview:

One of the most striking results to emerge from the LifePaths representation of time use is a greater recognition of how our impressions of the importance of paid work over the life cycle are affected by the “granularity” of the time accounting that is used. Conventional approaches tend to go year by year, in which case a typical working lifetime can be expected to extend over 20–40 years of the life cycle. However, when finer units of time (e.g., hours and days) are used, the proportion of unit time intervals over the typical life cycle that are dominated by market work becomes a much smaller fraction⁵⁵.

17. *Public Pensions – Canadian Analyses Based on the LifePaths Generational Accounting Framework*

Paper’s Abstract:

Public pensions in Canada, as in many countries, continue to be questioned in terms of their long-term fiscal sustainability, particularly given forecasts of demographic aging. As a result, a variety of reforms have been adopted or proposed, including privatisation. Privatisation of the public earnings-related pension, an option more

⁵³ Boothby D. and G. Rowe, 2002. “Rate of Return to Education: A distributional Analysis Using the LifePaths Model”, *Working Paper W-02-8E, Applied Research Branch, Strategic Policy, Human Resources Development Canada*, http://www.s3ri.soton.ac.uk/qmss/documents/RateofReturn_to_Education-DistributionalAnalysisusing_LifePaths.pdf, p. iii.

⁵⁴ Wolfson, M. C. and G. Rowe. 2001. “Perspectives on Working Time over the Life Cycle.”, In *Working Time in Comparative Perspective: Life-Cycle Working Time and Nonstandard Work*, Vol. 2, Susan Houseman, and Alice Nakamura, eds. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, http://research.upjohn.org/cgi/viewcontent.cgi?article=1384&context=up_bookchapters&seid=1#search=%22Perspectives%20Working%20Time%20Over%20Lifecycle%22, pp. 43–71.

⁵⁵ *Idem*.

actively discussed south of our border, is an option potentially with multiple layers of behavioural and/or institutional response. This paper examines several such layers – involving broad equity and bond market volatility, performance characteristics of mutual fund markets and individual risk aversion (or its complement represented as active trading). These are considered in a Canadian context using LifePaths GA (Generational Accounting), an overlapping generations microanalytic simulation model. The results suggest that privatisation of the public earnings-related pension could realistically result in reduced rates of return relative to the *status quo*. Comparisons among alternative scenarios indicate that inequalities generated by market volatility could be of a scale that would create public policy concerns⁵⁶.

18. *Trend Correlation of Labour Market Earnings in Canada: 1982 to 1995*

Paper's Abstract:

Using Statistics Canada's Longitudinal Administrative Database (LAD) data, this paper uniquely contributes to the understanding of stability of the labour market real earnings in CANada by using Kendall's rank correlation and significance test to identify the presence of career trends in earnings streams of individual tax payers. Distribution of the kendall's rank correlation for trend, lag correlation and partial correlation may be compared and will shed light on the stability of individual career in the labour market from 1982 to 1995. The availability of vast individual earnings data with over 1,5 million records of earnings information from the LAD database will provide useful information on rank measures and distributions on the individual careers in Canada⁵⁷.

19. *Modelling Labour Force Careers for the LifePaths Simulation Model*

Paper's Abstract:

We estimate the parameters of a stochastic model for labour force careers involving distributions of correlated durations employed, unemployed (with and without job search) and not in the labour force. If the model is to account for sub-annual labour force patterns as well as advancement towards retirement, then no single data source is adequate to inform it. However, it is possible to build up an approximation from a number of different sources⁵⁸.

⁵⁶ Wolfson, M.C., and G. Rowe. "Public Pensions – Canadian Analyses Based on the LifePaths Generational Accounting Framework", *6'th Nordic Seminar on Micro Simulation Models*, Copenhagen, Denmark, 2000,

<http://www.s3ri.soton.ac.uk/qmss/documents/PrivatizingPublicPensions-CanadianAnalyses.pdf>.

⁵⁷ Chen, E., and G. Rowe. "Trend Correlation of Labour Market Earnings in Canada: 1982 to 1995", *Annual Meeting of Statistical Society of Canada*, Winnipeg, Manitoba. (2000), p. 173.

⁵⁸ Rowe, G, and Lin, X., *Modelling Labour Force Careers for the LifePaths Simulation Model*, *Symposium 99, Combining Data from Different Sources Proceedings*, Ottawa, Statistics Canada, 57-63 (1999) <http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=11-522-X19990015648&lang=eng>.

20. *An Increment-Decrement Model of Secondary School Progression for Canadian Provinces*

Paper's Abstract:

A model of secondary school progression has been estimated using data from the 1991 School Leavers Survey conducted by Statistics Canada. The data on which the school progression model was based comprised current educational status and responses to retrospective questions on the timing of schooling events. These data were sufficient for approximate reconstruction of educational event histories of each respondent. The school progression model was designed to be included in a larger, continuous time micro-simulation model. Its main features involve estimation -- by age, month of birth and season for both sexes in each province -- of rates of graduation, of dropout, of return and of dropout graduation. Estimation was reinforced with auxiliary 1991 Census and administrative data⁵⁹.

21. *“Good Life Time” (GLT): Health, Income, and the Time to Enjoy Them*

Paper's Abstract :

Contemporary public policy increasingly takes an integrated view of individuals – in their family contexts, in their time spent in leisure and unpaid as well as paid work, and in their interactions with major government institutions such as schooling, health care, taxes and cash transfers. Moreover, policy-related information needs, as well as those of the general public, include both broad summary indices and detailed distributional patterns. However, there is no widely accepted integrated framework for socio-economic statistics that spans these domains, particularly one based on explicit and coherent microanalytic foundations. LifePaths is a prototype of such a framework under development at Statistics Canada. It builds on ideas developed for the UN's (1975) System of Social and Demographic Statistics, and Juster and Land's (1981) discussion of demographic versus time-based systems of social accounts. This paper extends earlier work sketching the initial LifePaths prototype (Wolfson, 1997) from a cross-sectional or period framework to an historical cohort, or equivalently an overlapping generations, framework. New illustrative results provide initial working estimates of the extent and distribution of “good life time”, defined as spells of leisure time over the life cycle that are coincident with adequate disposable income and health⁶⁰.

22. *Historical Generational Accounting with Heterogeneous Populations*

Paper's Introduction:

In the next section we begin the analysis by contrasting our approach to several others for judging intergenerational fairness and sustainability, particularly a new approach called Generational Accounting or GA (Kotlikoff, 1992; Oreopoulos and Kotlikoff, 1996; Oreopoulos and Vaillancourt in chapter 2). The driving factor in this GA analysis is accumulated government debt, rather than population aging. We then

⁵⁹ Rowe, G., and E. Chen, “An Increment-Decrement Model of Secondary School Progression for Canadian Provinces”, *Symposium 98, Longitudinal Data for Complex Analysis: Proceedings*, Statistics Canada, 167-178 (1998)

<http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?lang=eng&catno=11-522-X19980015034>.

⁶⁰ Wolfson, M.C., and G. Rowe, ““Good Life Time” (GLT): Health, Income, and the Time to Enjoy Them”, *CSLS Conference on the State of Living Standards and the Quality of Life in Canada*, October 30 - 31, 1998, <http://www.csls.ca/events/oct98/wolf.pdf>, p. 1.

present results based on a new form of generational accounting using the LifePaths microsimulation model developed at Statistics Canada. LifePaths GA generates estimates for large samples of realistically heterogeneous individual socio-economic life histories for all generations born during this century. These estimates can be used to provide information useful for judging the intergenerational fairness and sustainability of Canada's current tax/transfer system. But they lead us to conclude that "generation" is not the most useful category when assessing the redistributive effects of government; income and individual circumstances are more important⁶¹.

23. *Socio-Economic Statistics And Public Policy: A New Role For Microsimulation Modeling*

Paper's Abstract :

Users of socio-economic statistics typically want more and better information. Often, these needs can be met simply by more extensive data collections, subject to usual concerns over financial costs and survey respondent burdens. Users, particularly for public policy purposes, have also expressed a continuing, and as yet unfilled, demand for an integrated and coherent system of socio-economic statistics.

In this case, additional data will not be sufficient; the more important constraint is the absence of an agreed conceptual approach. In this paper, we briefly review the state of frameworks for social and economic statistics, including the kinds of socio-economic indicators users may want. These indicators are motivated first in general terms from basic principles and intuitive concepts, leaving aside for the moment the practicalities of their construction. We then show how a coherent structure of such indicators might be assembled.

A key implication is that this structure requires a coordinated network of surveys and data collection processes, and higher data quality standards. This in turn implies a breaking down of the "stovepipe" systems that typify much of the survey work in national statistical agencies (i.e. parallel but generally unrelated data "production lines"). Moreover, the data flowing from the network of surveys must be integrated. Since the data of interest are dynamic, the proposed method goes beyond statistical matching to microsimulation modeling. Finally, these ideas are illustrated with preliminary results from the LifePaths model currently under development in Statistics Canada⁶².

Paper's conclusion:

Space has not permitted other features to be graphically illustrated, such as the explicit micro data foundations and hence the capacity to display variety. Further work is required to illustrate other key features such as summary indicators (e.g. lifetime income distributions), and "what if" simulations. Still, the results presented constitute a substantial "proof by construction" of the practical and technical feasibility of the approach.

⁶¹ Wolfson, M.C., X. Lin and G. Rowe 1998. "Historical Generational Accounting with Heterogeneous Populations", in *Government Finances and Generational Equity*, Miles Corak (ed), Ottawa, Statistics Canada, <http://www.statcan.gc.ca/pub/68-513-x/68-513-x1997001-eng.pdf>, p. 108.

⁶² M. C. Wolfson, July 1995. "Socio-Economic Statistics And Public Policy: A New Role For Microsimulation Modeling", *Statistics Canada and the Canadian Institute for Advanced Research. No. 81*, A Paper Prepared for the 50th Session of the International Statistical Institute, Beijing, 21-29 August 1995 Invited Paper Meeting on "Changes in User Expectations About the Quality of Survey Statistics in the Public and Private Sector" <http://www.statcan.gc.ca/pub/11f0019m/11f0019m1995081-eng.pdf>, p. 6.

Chapter 5: Lifepaths

At the same time, the approach highlights gaps and weaknesses in existing socio-economic statistical data, particularly from a microanalytic perspective. The LifePaths approach would place much stronger demands on the coherence and quality of underlying socio-economic surveys and data collection systems. Given a measure of acceptance of the benefits for socio-economic statistical reporting of something like the LifePaths approach, it can provide the basis for strategic planning in national statistical agencies⁶³.

⁶³ *Ibid.*, p. 20.

Chapter 6: Persim

Designer: Statistics Canada, 2009

Description:

The aim of this paper is to describe PERSIM (short for Personnel Simulation Model) and demonstrate how this microsimulation model can be used to estimate the probable effects of personnel policy alternatives. PERSIM was developed by Statistics Canada. It is a demographically driven time-based microsimulation model using a Markov process. PERSIM can analyze a broad range of human resources (HR) issues including: recruitment, promotions, management succession, ageing and workforce representation. This paper describes three approaches employed by PERSIM. (1) The replacement model is designed to answer the question: how much staffing is required to maintain the current level of employment. (2) The succession model is designed to estimate the level of promotions required to maintain the organization's pyramidal structure. It also provides information on the "readiness" of the feeder pools based on years of experience. (3) The composition model modifies the workforce composition by using group specific probabilities. By adjusting the inflow probabilities, it estimates the level of recruitment required to change the representation of the workforce within a specific time frame. This paper will also discuss the requirements for the successful implementation of these approaches in the context of HR planning⁶⁴.

Users:

- Gravel, Martin (Statistics Canada)
- Kopersiewich, Robert (Statistics Canada)
- Lebel, André (Statistics Canada)
- Picot, Garnett (Statistics Canada)
- Wannell, Ted (Statistics Canada)

Applications:

1. *Management Experience and Diversity in an Aging Organization: A Microsimulation Analysis*

Paper's Abstract:

The aging of the Canadian population is a well recognized phenomenon and has received considerable policy research attention, particularly in the health and public pension domains. Very little work has been focused on the impacts of aging at the organizational level. Foot and Venne studied the advancement of the baby boom through traditional organizational hierarchies, noting its impacts on human resource policies that encourage horizontal career development. Saba et al looked more

⁶⁴ Lebel A. and R. Kopersiewich, "Using PERSIM for Effective Human Resources Planning", Poster Session, *International Microsimulation organization 2009*, <http://www.statcan.gc.ca/conferences/ima-aim2009/poster-session-affiche-eng.htm#a15>

particularly at the management of older professionals in the Quebec public service, finding that employee recognition was an important human resource strategy for motivating this group. We extend these studies further along the aging ladder—to the point where retirement and replacement become the major concerns.

Looking at the management hierarchy within Statistics Canada, we use a microsimulation model first to estimate the expected level of retirements over the next 10 years. We then detail the adjustments to promotion and hiring rates required to replace outgoing managers. We then examine simulated microdata to estimate the experience effects of increasing turnover. Finally, we use the demographic features of the model to examine whether the increasing turnover is likely to increase the representation of women and visible minorities among Statistics Canada managers.

Given the assumptions outlined in the paper, we find that increasing turnover rates in the next 10 years will generally not reduce management experience to below recently observed levels. We also find that given equal promotion rates for men and women, the representation rate of women among Statistics Canada managers is likely to increase rapidly in coming years. On the other hand, visible minority representation among managers will likely stall for several years, even with proactive recruitment and advancement policies⁶⁵.

2. *Micro-Simulation Studies of the Status of Women and Minorities in Government Organizations*

Paper's Introduction:

The level of representation of women and “visible” minorities, those whose skin colour allow them to be readily identified, in the Canadian federal government has been an issue for some time. In 1990 a major task force, “Beneath the Veneer”, concluded that women were concentrated in lower paying occupations with little opportunity for advancement. More recently, a similar task force, “Embracing Change”, concluded that visible minorities are under-represented at almost all levels. The task force proposed that one-fifth of all people recruited to the federal government, and one-fifth of people promoted to the executive level, should be visible minorities, a group that now accounts for 8% of federal employment. The idea is to dramatically increase the employment flows for minorities (hiring, promotions) so that their representation in government will rise quickly. Even more recently, the human rights commission conducted an audit of employment shares for women and visible minorities, and established targets. These recommendations and targets raise questions regarding the speed at which the representation rates for women and visible minorities can in fact change. Typically, very large changes in employment flows (recruitment, promotions, exits) are required to make relatively small changes in the composition of total employment. Reports that seek to improve the participation of under-represented groups tend to focus on recommendations that will influence the levels of recruitment, promotions or exits for these groups. Assessing the progress in overall representation rates that might reasonably be expected from changes in these employee flows requires simulations of future employment levels and distributions. It is necessary to ask “what if” questions, such as “If recruitment shares for women are increased to 50%, what effect will that have on female representation rates at the junior, intermediate and senior job levels over the next ten years?” Most organizations do not have the tools available to ask such questions. Implementing a useful simulation model can assist in evaluating and

⁶⁵ Wannell T. and M. Gravel, August 2002. “Management Experience and Diversity in an Aging Organization: A Microsimulation Analysis”, Business and labor market analysis division, Statistics Canada, <http://www.statcan.gc.ca/pub/11f0019m/11f0019m2002188-eng.pdf>, p. 6.

developing strategies to improve the representation of women and visible minorities⁶⁶.

⁶⁶ Picot G. and T. Wannell, [Year of Publication not available], “Micro-Simulation Studies of the Status of Women and Minorities in Government Organizations”, *Statistics Canada*, <http://isi.cbs.nl/iamamember/CD2/pdf/1078.PDF>, p. 1.

Chapter 7: The Population Health Model (POHEM)

Designer: Statistics Canada, 1992

Description:

The Population Health Model (POHEM) is a microsimulation model of diseases and risk factors in which the basic unit of analysis is the individual person. The simulation creates and ages a large sample population representative of Canada, one individual at a time, until death. The life trajectory of each simulated person unfolds by exposure to different life-like events, such as smoking initiation and cessation, changes in weight, and incidence and progression of diseases such as osteoarthritis, cancer, diabetes and heart disease. POHEM combines data from a wide range of sources, including nationally representative cross-sectional and longitudinal surveys, cancer registries, hospitalization databases, vital statistics, Census, treatment cost data as well as parameters in the published literature. The model inputs may also be altered at the user's request to investigate 'what if' scenarios. These scenarios can be very useful for policy makers, by providing information beyond what is available from retrospective population studies. Earlier versions of POHEM were used to estimate lifetime costs of breast and colorectal cancer, as well as assessments of health technology on cancer control, such as chemotherapy options for advanced stage lung cancer, use of preventive Tamoxifen on Canadian women, and impact of population-based colorectal cancer screening. More recent generations of POHEM models have been developed for other common diseases such as osteoarthritis, acute myocardial infarction and diabetes, as well as for disease risk factors such as obesity and physical inactivity. The risk factor modules enable users to simulate the impacts of the changes of obesity or physical activities on key health outcomes⁶⁷.

Users:

- Berthelot, Jean-Marie (Vice President of Programs, CIHI)
- Coombs, Ann (Health Canada)
- Edge, Victoria (Public Health Agency of Canada)
- Evans, W. K. (Ottawa Regional Cancer Centre and University of Ottawa)
- Finès, Philippe (Health Analysis Division at Statistics Canada)
- Flanagan, William (Statistics Canada)
- Garriguet, Didier (Statistics Canada)
- Gillis, Daniel (Public Health Agency of Canada)
- Gribble, Steve (Statistics Canada)
- Houle, Christian (Health Analysis and Modeling Group, Statistics Canada)
- Jones-McLean, Elaine (Health Canada)
- Kopec, Jacek A. (School of Population and Public Health)
- Lee, Douglas
- Le Petit, Christel (Statistics Canada)
- Manuel, Doug (Ottawa Hospital Research Institute; Statistics Canada; University of Ottawa)
- Nadeau, Claude (Statistics Canada)

⁶⁷ Statistics Canada, "Population Health Model", Publications : Microsimulation, Statistics Canada, Health Models, <http://www.statcan.gc.ca/microsimulation/health-sante/health-sante-eng.htm>.

- Oderkirk, Jilian (Statistics Canada)
- Omariba, Walter (University of Toronto)
- Rahman, Mushfiqur (School of Population & Public Health, University of British Columbia ; Arthritis research center of Canada)
- Rowe, Geoff (Socio-Economic Analysis and Modeling Division Analysis and Development Branch, Statistics Canada)
- Sayre, Eric C. (Arthritis Research Centre of Canada; Simon Fraser University)
- Tremblay, Mark (Children's Hospital of Eastern Ontario; University of Ottawa)
- Wadell-Trumble, Jan (Public Health Agency of Canada)
- Wall, Ron (Public Health Agency of Canada)
- White, Kathleen (Statistics Canada)
- Will, B.P. (Health Analysis and Modeling Group, Statistics Canada)
- Wolfson, Michael C. (Statistics Canada)

Applications:

1. *Population Health Model - Physical Activity Dynamic Model*

Paper's Abstract :

Physical activity is an important determinant of health and how active Canadians will be in the future will have important consequences. Lack of physical activity has been associated with elevated risk of a wide variety of chronic health conditions such as diabetes, hypertension, cardiovascular disease and certain cancers. We used the Population Health Model (POHEM), a dynamic microsimulation framework that projects a representative sample of the Canadian population, to build a decision making tool for the Public Health Agency of Canada in support of new policies and programs to address physical inactivity in Canada. Regression models for physical activity and chronic conditions were estimated from individual level, longitudinal, self-report data from large nationally representative Canadian surveys conducted every two years from 1994 to 2006, and included a wide range of explanatory variables, such as age, sex, income, education, ethnicity, smoking, obesity, and past levels of physical activity. To account for parameter uncertainty, we used bootstrapping techniques and projected confidence bands. We performed what-if scenarios to evaluate the potential impact on health if physical activity trends could be altered. Preliminary results suggest that if all Canadians walked 5 hours per week and engaged in at least one hour of leisure time activity, life expectancy could be increased by 2 years and health-adjusted life expectancy by 3 years, thereby living healthier and longer⁶⁸.

⁶⁸ Nadeau, C., W. Flanagan, J. Oderkirk, G. Rowe, V. Edge, D. Gillis, R. Wall, D. Manuel, M. Tremblay, J. Trumble Waddell, 2011. "Population Health Model - Physical Activity Dynamic Model", http://www.scb.se/Grupp/Produkter/Tjanster/Kurser/Dokument/IMA/Flanagan_POHEM_PhysicalActivityModel_IMApaper_2011.pdf, p. 3.

2. *Microsimulation of osteoarthritis in Canada – Case study of a chronic disease in Canada*

Overview:

Osteoarthritis (OA) is a highly prevalent chronic disease. Using a sophisticated discrete-event, Monte Carlo, microsimulation tool called the Population Health Model, we have developed an evidence-based model for the evolution of OA in Canada (POHEM-OA). With data from national health surveys and hospital records, we were able to project prevalence and incidence of OA from 2001 to 2021. Incidence of OA was modeled as a stochastic process and implemented in continuous time. Prevalence was calibrated to be consistent with observed incidence rates. When OA occurred for an individual, time to a visit to an orthopedic surgeon (OS) was modeled using a survival function: a random number extracted from the inverse of a 2-piece Weibull survival function was converted into the time to the OS visit. When an OS visit occurred, next OS visit and surgery were modeled as competing events; the one with the smallest time was realized. Similarly, after surgery, next surgery and revision were competing events. Death could occur at anytime, according to life table mortality hazards. Health Utility Index 3 was computed regularly, according to specific statistical models built from national health surveys. All of these components led to a consistent model of OA; they were implemented in POHEM-OA as parameters which varied by sex, age category and category of body mass index. In this presentation, we examine the technical aspects of each step involved in building the model⁶⁹.

3. *Projecting incidence of acute myocardial infarction using microsimulation*

Overview:

Objective: To project incidence of first acute myocardial infarctions (AMI) from 2001 to 2021, and evaluate the impact of cardiac risk factors on AMI through counterfactual analysis.

Methods: We used the POHEM microsimulation to project a representative sample of the Canadian population: CCHS (2000–2001). The Framingham risk equation was calibrated to Canadian AMI incidence, obtained from hospital discharge databases (2000/01). Increasing obesity and decreasing smoking trends from NPHS (1994–2004) were projected. Cholesterol, diabetes, and hypertension prevalence was estimated from CHHS (1986–1992). Counterfactual analyses evaluated the impact of reduced cardiac risk factor prevalence, and adherence to guidelines for lipid-lowering statin therapy. Projections were validated against observed hospitalizations for first AMI from 2000/1–2004/5.

Results: The number of first AMIs was projected to increase from 41,000 in 2001 to 51,000 in 2009, reaching 66,000 in 2021 (approximately 1300 per year). Age-standardized rates declined somewhat over this period, mainly due to the projected decline in smoking. Interventions on multiple cardiac risk factors could reduce the burden of first AMI by 7% (3600 per year); 50% adherence to statin therapy projected a 6% reduction in AMI (3200 per year).

Conclusion: Future increased burden of AMI was mainly attributable to population aging. Lifestyle changes and drug therapy could reduce this burden. Our baseline projections of AMI exceed observed data, whereas our intervention scenarios

⁶⁹ Finès, P., J. A. Kopec, W. M. Flanagan, E. C. Sayre and Md. Mushfiqur Rahman (Statistics Canada, HIRD, Pohem), “Microsimulation of osteoarthritis in Canada – Case study of a chronic disease in Canada”, *International Microsimulation Association 2009, Abstracts – Session 1B*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1b-eng.htm#a18>.

underestimate it. This difference may be due to coding/classification changes and/or new therapies, and/or lower than 50% adherence to statins. Microsimulation can be useful for evaluating hypothetical future scenarios to inform policy⁷⁰.

4. *Modelling the impacts of colorectal cancer screening in Canada using POHEM*

Paper's Abstract :

Introduction: Colorectal cancer (CRC) is the second cause of cancer deaths in Canada. Randomized controlled trials (RCT) have shown the efficacy of screening using faecal occult blood tests (FOBT). A comprehensive evaluation of the costs and consequences of colorectal cancer screening for the Canadian population is required before implementation of such a program. **Methods:** Statistics Canada's Population Health microsimulation Model was updated to incorporate a comprehensive CRC screening module based on Canadian data and RCT efficacy results. The module incorporated sensitivity and specificity of FOBT and colonoscopy, participation rates, incidence, staging, diagnostic and therapeutic options, disease progression, mortality and direct health care costs for different screening scenarios. Reproducing the mortality reduction observed in the Funen screening trial validated the model. **Results:** A biennial screening program with a 67% participation rate offered to individuals aged 50-74 years of age, was estimated to produce a 16.7 % reduction in CRC 10-year mortality for the cohort of Canadians subjected to screening in the year 2000. The lifetime benefit of CRC screening was estimated to result in an overall increase in life expectancy of 0.04 years (15 days) (undiscounted). The average annual cost over a 25-year period was estimated at \$112 million (discounted at 5%). The cost effectiveness was estimated to be \$11,907 per life year gained (discounted at 5%). **Conclusions:** CRC screening appears cost-effective under all the scenarios considered. The results of these simulations will be provided to the Canadian National Committee on Colorectal Cancer Screening to help formulate national policy recommendations for CRC screening⁷¹.

5. *Use of POHEM to Estimate Direct Medical Costs of Current Practice and New Treatments Associated with Lung Cancer in Canada*

Paper's Abstract :

Context : Lung cancer has been the leading cause of cancer deaths in Canadian males for many years, and since 1994, this has been the case for Canadian females as well. It is therefore important to evaluate the resources required for its diagnosis and treatment. This article presents an estimate of the direct medical costs associated with the diagnosis and treatment of lung cancer calculated through the use of a micro-simulation model. For disease incidence, 1992 was chosen as the reference year, whereas costs are evaluated according to the rates that prevailed in 1993.

Methods : A model for lung cancer has been incorporated into the Population Health Model (POHEM). The parameters of the model were drawn in part from Statistics Canada's Canadian Cancer Registry (CCR), which provides information on the incidence and histological classification of lung cancer cases in Canada. The distribution of cancer stage at diagnosis was estimated by using information from

⁷⁰ Flanagan, W., D. Lee, D. Manuel, P. Finès, C. Nadeau, W. Omariba, J. Oderkirk, "Projecting incidence of acute myocardial infarction using microsimulation", *International Microsimulation Association 2009, Abstracts – Session 1B*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1b-eng.htm#a18>.

⁷¹ Le Petit, F. W., C., Berthelot, J.-M., White, K.J., Coombs, B.A., E. Jones-McLean, "Potential Impact of Population-based Colorectal Cancer Screening in Canada". *Chronic Dis. Can.* 2003; 24 (4) in press. <http://www.statcan.gc.ca/pub/11-522-x/2002001/session3/6722-eng.pdf>.

two provincial cancer registries. A team of oncologists derived “typical” treatment approaches reflective of current practice, and the associated direct costs were calculated for these approaches. Once this information and the appropriate survival curves were incorporated into the POHEM model, overall costs of treatment were estimated by means of a Monte Carlo simulation.

Results: It is estimated that overall, the direct medical costs of lung cancer diagnosis and treatment were just over \$528 million. The cost per year of life gained as a result of treatment of the disease was approximately \$19,450. For the first time in Canada, it was possible to estimate the five year costs following diagnosis, by stage of the disease at the time of diagnosis. It was possible to estimate the cost per year of additional life gained for three alternative treatments of non small-cell lung cancer (NSCLC). Sensitivity analyses showed that these costs varied between \$1,870 and \$6,860 per year of additional life gained, which compares favourably with the costs that the treatment of other diseases may involve.

Conclusions: Contrary to widespread perceptions, it appears that the treatment of lung cancer is effective from an economic standpoint. In addition, the use of a micro-simulation model such as POHEM not only makes it possible to incorporate information from various sources in a coherent manner but also offers the possibility of estimating the effect of alternative medical procedures from the standpoint of financial pressures on the health care system⁷².

6. *POHEM : a framework for understanding and modeling the health of human populations*

Abstract :

A variety of developments have come together to serve as both an impetus to and foundation for the development of a new POpulation HEalth Model (POHEM) at Statistics Canada. Part of the impetus is statistical and derives from weaknesses in Canada's health statistics programme--particularly the lack of balance between information on health outcomes and health care resource consumption, and the absence of a coherent statistical structure. The other major impetus is the need for rational processes for managing and allocating resources to improve the health of Canadians. The foundation for the development of this model has come from the revolution in computing. Dramatic improvements have opened up new methodological opportunities, particularly sophisticated simulation modelling and detailed analyses of large volumes of microdata. POHEM is designed to build on these increasingly powerful methods in order to meet health statistical and policy needs. At this time, POHEM is like a partially-completed building. This article reviews its motivation, the overall architectural plan, and the portion of the structure already completed. A major portion of POHEM is devoted to the explicit modelling of chronic disease processes, using monte carlo microsimulation methods. The article concludes with illustrations of a few recent applications, focusing on the joint patterns of smoking, cholesterol and heart disease, osteoarthritis and lung cancer morbidity. While POHEM has been developed in a Canadian context, work is under way to create a version that can be used in other countries⁷³.

⁷² Houle, C., B.P. Will, J.-M. Berthelot, Dr. W. K. Evans, February 1997. “Use of POHEM to Estimate Direct Medical Costs of Current Practice and New Treatments Associated with Lung Cancer in Canada”, *Statistics Canada, The Analytical Studies Branch Research Paper Series*, No. 99, <http://www.statcan.gc.ca/pub/11f0019m/11f0019m1997099-eng.pdf>.

⁷³ Wolfson, M.C., “POHEM – a framework for understanding and modelling the health of human populations”, *World Health Stat*, Q. 1994; 47 (3-4) : 157-76. PubMed PMID : 7740830, <http://www.ncbi.nlm.nih.gov/pubmed/7740830>.

7. *POHEM – A new Approach to the Estimation of Health Status adjusted Life Expectancy*

Abstract :

This paper describes a general methodology for estimating life expectancy adjusted for variations in health status during the course of individuals' lifetimes — the population health model, POHEM. Measures such as "disability-free life expectancy" and the life table methodology on which these kinds of indices are based are considered. The restrictions embodied in such measures and their underlying methodologies can be conveniently avoided with the POHEM microsimulation approach. Prototypical outputs of POHEM are presented, and it is argued that the POHEM methodology is not unduly complex. Many countries could use it to generate health status adjusted life expectancy indices given already available data. Moreover, POHEM provides a framework for integrating a range of health data and for producing a family of important health indices⁷⁴.

⁷⁴ Wolfson, M. C., « POHEM : une approche inédite pour l'estimation de l'espérance de vie corrigée en fonction de l'état de santé », *Cahiers québécois de démographie*, Volume 20, numéro 2, automne 1991, p. 329-365, <http://id.erudit.org/iderudit/010089ar>.

Chapter 8: The Riskpaths Teaching Model

Designer: Statistics Canada (2007)

Description:

RiskPaths is a simple, competing risk, continuous time microsimulation model developed alongside a microsimulation course for the European Doctoral School for Demography. It enables the study of how childlessness and other measures are affected at an aggregate level by changes in individual processes, such as fertility by age, first and second union formation, and union dissolution. While kept simple, RiskPaths nevertheless demonstrates what microsimulation can add to event history analysis and how demographic microsimulation models can be efficiently programmed using the language Modgen. The output of RiskPaths includes the visual display of how individual risks of the modeled events change over the simulated life courses, thus allowing students to better understand the underlying hazard regression models and the concept of competing risks. Table output includes the simulated values of the initial model parameters, a feature which supports the study of randomness and its connection to sample size⁷⁵.

Users:

- Bélanger, Alain (Centre – Urbanisation Culture Société national de la recherche scientifique (INRS))
- Kostova, Dora (Max Planck Institute for Demographic Research)
- Koytcheva, Elena (Max Planck Institute for Demographic Research)
- Morency, Jean-Dominique (Centre – Urbanisation Culture Société national de la recherche scientifique (INRS))
- Nguyen, Huan (Socio-Economic Analysis and Modeling Division Analysis and Development Branch Statistics Canada)
- Rowe, Geoff (Socio-Economic Analysis and Modeling Division Analysis and Development Branch Statistics Canada)
- Spielauer, Martin (Modeling Division, Statistics Canada)

Applications:

1. *A Microsimulation Model to Study the Interaction between Fertility and Union Formation and Dissolution: An Application to Canada and Quebec*

Paper's Abstract:

Union formation and dissolution are among the main determinants explaining variations in fertility. Compared to the rest of Canada, Quebec's marital histories are more complex and its prevalence of common-law unions much higher. The objective of this article is to examine the role of marital behaviours on fertility by comparing

⁷⁵Statistics Canada, "The Lifepaths Teaching Model", *International Microsimulation Association 2009, Abstracts – Session 2D*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session2d-eng.htm#a7>.

different indicators of fertility and conjugal life that were obtained through microsimulation. Parameters of the microsimulation model were estimated from hazard regressions performed on the marital and fertility histories collected in two retrospective longitudinal surveys: the Canadian General Social Survey (GSS) 2001 and 2006.

Results :

Results show that the more complex marital histories of Quebecers can explain more than one-quarter of their fertility differences with the rest of the country⁷⁶.

2. *General Characteristics of MODGEN Applications: exploring the Model Riskpaths*

Paper's Introduction:

In this discussion we introduce a simple microsimulation model called RiskPaths that has been implemented using Modgen. We start with a description of its underlying statistical models and then explore follow-up questions, such as what microsimulation can add to the initial statistical analysis and what other benefits microsimulation can bring to the overall analysis. We then demonstrate parts of Modgen's visual interface to examine elements of the RiskPaths model⁷⁷.

3. *Modgen and the application RiskPaths from the Model Developer's View*

Paper's introduction:

In this chapter we explore the microsimulation model development package Modgen and the Modgen application RiskPaths from the model developer's point of view. We first introduce the Modgen programming environment, and then discuss basic Modgen language concepts and the RiskPaths code. Modgen requires only moderate programming skills; thus, after some training, it enables social scientists to create their own models without the need for professional programmers. This is possible because Modgen hides underlying mechanisms like event queuing and automatically creates a stand-alone model with a complete visual interface, including scenario management and model documentation (as introduced in the previous chapter). Model developers can therefore concentrate on model specific code: the declaration of parameters, the states defining the simulated actors, and the events changing the states. High efficiency coding extends also to model output. Modgen includes a powerful language to handle continuous time tabulation. These tabulations are created on-the-fly when simulations are run and the programming to generate them usually requires only a few lines of code per table. Modgen also has a built-in

⁷⁶ Bélanger, A., J.-D. Morency, M. Spielauer, 2010. „A Microsimulation Model to Study the Interaction between Fertility and Union Formation and Dissolution: An Application to Canada and Quebec”, *Canadian Studies in Population*, Vol. 37.3-4, Fall/Winter, <http://web.uvic.ca/~canpop/journal/2010/CSPv37n3-4p339.pdf>, p. 339.

⁷⁷ Spielauer, M., 2009. “General Characteristics of MODGEN Applications: exploring the Model Riskpaths”, *Statistics Canada – Modeling Division*, <http://www.statcan.gc.ca/microsimulation/pdf/chap3-eng.pdf>, p. 1-2.

mechanism for estimating the Monte Carlo variation for any cell of any table, without requiring any programming by the model developer⁷⁸.

4. *First and second births in first and second unions: a decomposition of fertility decline in Bulgaria and Russia since the 1989 economic and political transition*

Paper's Abstract:

Following the collapse of the communist regimes in Bulgaria and Russia, the two countries have experienced dramatic fertility decline. The aim of this paper is to examine the individual contribution of various factors that have contributed to the overall drop in first and second births. By means of microsimulation, we isolate the effect of changes observed in first and second birth risks in different life course situations as well as the impact of changes in union formation and dissolution on fertility. The study is based on hazard regression models estimated from GGS data. We find remarkable similarities in first and second birth behavior and changes in these behaviors over time in both countries. However, partnership behavior and trends differ considerably, causing a stronger fertility decline in Bulgaria due to delayed partnership formation. Nevertheless, in Russia unions are increasingly unstable, a process which, according to our findings, leads to longer birth intervals but has almost no impact on final birth outcome⁷⁹.

5. *Convergence of Male and Female Patterns of Employment Activity (IV-F)*

Paper's Abstract:

The steady convergence of men and women's employment/population ratios has been one of the most dramatic changes observed in the Canadian labour market over, at least, the past 25 years. Indeed, it is probable that, within the population as a whole, gender differences in work behaviour are now substantially less important than differences in skill levels. Nevertheless, there may be persistent differences in the dynamics of employment activity between men and women; for example, differences that are more apparent in relation to job tenure and job transitions. We will try to reconcile the evidence favouring continued convergence with evidence of persistent differences, in order to motivate a range of projection scenarios for Canada's labour market. In our examination of men and women's employment dynamics, we make use of data from the Canadian Labour Force Survey (LFS) on transitions among the labour market states: *self-employed*, *paid employee* and *not employed*. The LFS was not designed to be a longitudinal survey. However, given that respondent households typically remain in the sample for six consecutive months, it is possible to reconstruct sixmonth fragments of longitudinal data from the monthly records of household members. Such longitudinal micro-data – altogether consisting of millions of person-months of individual and family level data – is useful for analyses of monthly labour market dynamics over relatively long periods of time, 25 years and more⁸⁰

⁷⁸ Spielauer, M., 2009. "Modgen and the application RiskPaths from the Model Developer's View", *Statistics Canada – Modeling Division*, <http://www.statcan.gc.ca/microsimulation/pdf/chap4-eng.pdf>, p. 1-2.

⁷⁹ Spielauer, M., E. Koytcheva, D. Kostova, December 2006. "First and second births in first and second unions: a decomposition of fertility decline in Bulgaria and Russia since the 1989 economic and political transition", *Max Planck Institute for Demographic Research*, <http://www.demogr.mpg.de/papers/working/wp-2007-001.pdf>.

⁸⁰ Rowe, G., and H. Nguyen, [year of publication not available] "Convergence of Male and Female Patterns of Employment Activity (IV-F)", *Socio-Economic Analysis and Modeling Division Analysis and Development Branch, Statistics Canada*, <http://www.statcan.gc.ca/pub/11f0024m/pdf/papers-etudes/4224998-eng.pdf>, p. 1.

Chapter 9: Ruthen

Designer: Richard Morrison (form. DYNACAN team)

Description:

Governments and institutions have generally built microsimulation models to address broad distributional policy issues. Seeking to assess the likely impacts of tax or social security proposal, they use the models to look at aggregate impacts or distributions of winners and losers. The past quarter century in particular has seen powerful advances for static, point-in-time models, and for longitudinal models. At the same time, model builders have not generally sought to adapt these powerful tools to the economic issues that individuals face, e.g., whether or how best to save for retirement, or how, after retirement, to draw down those savings. However, substantial portions of the infrastructure for longitudinal microsimulation modeling would transfer well to addressing these individual-level decisions. This paper outlines how such an adaptation might proceed. It describes the contributions that such adaptation would make, not only for actual or representative individuals, but also for institutional and governmental consumers of microsimulation analyses. The paper's several sections describe what the models, and their target problems, and their results, might look like. They indicate what portions of standard microsimulation technologies the models might usefully borrow, what new technologies and methodologies one would have to develop, how the development might proceed, and the set of issues the models might address. A concluding section indicates how one might develop a feasibility demonstration version of the approach⁸¹.

Users:

- Avery, Marvin (form. DYNACAN team)
- Morrison, Richard (form. DYNACAN team)

Applications:

1. *Microsimulation as a Financial Literacy Tool: Assessing the Consequences of Decisions to Work, Save, Retire, and Spend*

Paper's Abstract:

⁸¹ Morrison, R., July 2007. Ruthen, run the numbers: longitudinal microsimulation for individuals, http://www.euro.centre.org/ima2007/programme/papers/Morrison1_abs.doc.

Ruthen-1 established the feasibility of using microsimulation for individuals, to inform their personal strategies for spending down portfolios to finance consumption in retirement, this in the face of uncertainties about mortality, inflation, and investment returns. Simulating millions of independent lifetimes generated distributions of outcomes flowing from the drawdown strategies, revealing major differences across alternative strategies for managing a given retirement portfolio. However, Ruthen-1's primary purpose was as a feasibility demonstration – establishing an experience base toward the development of a more ambitious, more practical, package in support of financial literacy.

This paper describes the lessons learned, and the design requirements and principles for the next generation “Ruthen-2” modeling package that is currently under construction. In briefest highlight –

- Technically, the new package implements a modeling language that is purpose-built to describe portfolios and the strategies used to manage them. It incorporates a much richer set of building blocks in the form of assets, incomes, loans, and expenses, plus a variety of operations on them. Improved output facilities provide greater convenience, more power, and actively support model validation.
- Substantively, these extensions permit one to address a much broader range of issues, from the treatment of couples, including divorce and survivorship, through retirement timing decisions, to more general objective functions, sensitivity analyses and optimization, and a first pass at the asset accumulation phase. As well, the language-based approach permits users to model arbitrary tax/transfer systems, including building models for other countries⁸².

2. *Retirement Savings and Retirement Consumption: Incentives-Based Analyses of Supposed Anomalies*

Paper's Abstract:

Analysts note that, with the decline of defined benefit pension plans, one of the most pressing needs of retiring Canadians is responsible advice on how to spend down their retirement portfolios. The exploratory Ruthen-1 microsimulation model directly addresses this financial literacy challenge. It calculates the distributions of outcomes associated with alternative draw-down strategies, this in the face of complex tax/transfer systems, and the inherent uncertainties associated with inflation, mortality, and investment returns. The Ruthen model is atypical in its focus on the outcomes and incentives relevant for individual retirees, rather than for government policies. This approach enables it to generate incentives-oriented results for a variety of recurring policy issues associated with major retirement “anomalies.” Following a summary description of the Ruthen-1 model, the paper provides illustrative analyses for several such issues.

- “Use it or lose it” – choosing how fast to spend retirement savings to optimize lifetime consumption
- “Gaming the system” – choosing how to hold wealth to improve consumption in retirement
- “How much difference do retirement assets make?” – measuring how much difference a given level of retirement savings makes to one's consumption in retirement
- “Is retirement saving worth the cost?” – deriving lifetime internal rates of return on retirement saving

⁸² Avery, M. & R. J. Morrison, May 2011, “Microsimulation as a Financial Literacy Tool: Assessing the Consequences of Decisions to Work, Save, Retire, and Spend”, *A paper prepared for the June 2011 International Microsimulation Association meetings in Stockholm, Sweden*, http://www.scb.se/Grupp/Produkter_Tjanster/Kurser/ Dokument/IMA/Microsimulation_as_a_Financial_Literacy_Tool.pdf.

- “Retirement saving: cui bono?” – assessing government sector returns to individuals’ saving for retirement

The Ruthen results suggest that there may be powerful systemic incentives leading to the saving and spending behaviours that appear to cause so much frustration for governments, financial institutions, and financial advisers. These results may generalize to other countries⁸³.

⁸³ Avery, M. & R. J. Morrison, May 2011. “Retirement Savings and Retirement Consumption: Incentives-Based Analyses of Supposed Anomalies”, *A paper prepared for the June 2011 International Microsimulation Association meetings in Stockholm, Sweden*, http://www.scb.se/Grupp/Produkter/Tjanster/Kurser/Dokument/IMA/Morrison_Retirement_Savings_and_Retirement_Consumption.pdf.

Chapter 10: The Social Policy Simulation Database and Model (SPSD/M)

Designer: Statistics Canada, 1998

Description:

The Social Policy Simulation Database and Model (SPSD/M) is a tool designed to assist those interested in analyzing the financial interactions of governments and individuals in Canada. It can help one to assess the cost implications or income redistributive effects of changes in the personal taxation and cash transfer system. As the name implies, SPSPD/M consists of two integrated parts: a database (SPSD), and a model (SPSM). The SPSPD is a non-confidential, statistically representative database of individuals in their family context, with enough information on each individual to compute taxes paid to and cash transfers received from government. The SPSM is a static accounting model which processes each individual and family on the SPSPD, calculates taxes and transfers using legislated or proposed programs and algorithms, and reports on the results. A sophisticated software environment gives the user a high degree of control over the inputs and outputs to the model and can allow the user to modify existing programs or test proposals for entirely new programs. The model comes with full documentation including an on-line help facility⁸⁴.

Users:

- Bibi, Sami (Université Laval)
- Brown, Shawna (Socio-Economic Analysis and Modeling Division at Statistics Canada)
- Chung, Jackson (Income Statistics Division, Statistics Canada)
- Clavet, Nicholas-James (Université Laval)
- Duclos, Jean-Yves (Université Laval)
- Fortin, Bernard (Université Laval)
- Hicks, Chantal (Socio-Economic Analysis and Modeling Division, Statistics Canada)
- Hwong, Thaddeus (York University)
- Murphy, Brian (Statistics Canada)
- Plager, Laurie (Statistics Canada)

⁸⁴ Statistics Canada, *SPSD/M, Product Overview*, <http://www.statcan.gc.ca/spsd/OVERVIEWE.pdf>.

Applications:

1. *Québec's 2008 Tax Reform : Impacts on social well being*

Paper's Abstract :

This paper presents the results of an assessment of the impact that a tax reform which involves raising the tax bracket thresholds in Quebec, Canada, has on the well-being of women living alone. Taxation rates are adjusted internally by maintaining constant tax revenues. To conduct this simulation, we use the Survey of Labour and Income Dynamics (SLID) and the Social Policy Simulation Database and Model (SPSD/M). The Canadian Tax and Credit Simulator (CTaCS) application is used to model each person's budget constraint. The behaviour of women is simulated with a discrete choice labour supply model (a translog utility function) that includes fixed costs. The model is estimated with a mixed logit. The results point to a slight overall increase in hours worked following the simulated reform. However, the reform has a negative impact on hours worked for one woman in three and no impact for one woman in five. Following estimation of the labour supply function, the individual expenditure function is incorporated into social well-being indicators such as the Gini coefficient and the Atkinson index⁸⁵.

2. *The importance of the database in tax/transfer modeling*

Overview :

This paper will examine the importance of data in tax/transfer modeling by running a single microsimulation model on different databases and comparing the results. The Social Policy Simulation Model (SPSM), a Canadian static tax/transfer model which has been publicly available since 1988, will be used. It will be run on a number of databases including the Survey of Labour and Income Dynamics (SLID), administrative tax records (the T1 family file) and the synthetic Social Policy Simulation Database (SPSD). The paper will then examine which database characteristics have the greatest impact on the estimate of total taxes and transfers as well as the distribution of taxes and transfers. Characteristics that will be investigated include the availability of deductions, the definition of the family, the sample size, the sampling frame, and the number of high income individuals.⁸⁶

3. *Income Distributional Outcomes of Converting Non-refundable Credits to Refundable Credits in Canada*

⁸⁵ Bibi, S., Clavet, N.-J., Duclos, J.-Y. et B. Fortin, "Québec's 2008 Tax Reform : Impacts on social well being", *International Microsimulation Association 2009*, Abstracts – Session 1B, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1b-eng.htm>.

⁸⁶ Brown, S., J. Chung, C. Hicks, and L. Plager, "The importance of the database in tax/transfer modeling", *International Microsimulation Association 2009*, Abstracts – Session 1A, <http://www.statcan.gc.ca/conferences/ima-aim2009/session1a-fra.htm#a7>.

Overview :

Many tax credits in Canada are non-refundable. Using Social Policy Simulation Database and Model (SPSD/M), the paper seeks to examine the income distributional outcomes of converting existing non-refundable credits to refundable credits in Canada. The paper will also explore the impacts of converting some credits to deductions. The credits essentially cover many tax expenditure programs on family and children, seniors, persons with disabilities as well health, education and charitable donations. The key question asked is what the income distributional outcomes of the conversion will likely be. SPSD/M, a Statistics Canada software, is a static microsimulation package designed to enable researchers to explore social policy outcomes in Canada⁸⁷.

4. *The Age Distribution of the Tax/Transfer System in Canada*

Paper's Introduction:

A clear understanding of the size and extent of intergenerational transfers made by governments is central to any informed debate dealing with "Intergenerational Equity." Accordingly, the aim of this chapter is to provide a descriptive backdrop to these discussions by examining how current policy at all levels of government in Canada redistributes income among the different generations. Who pays the taxes and who receives the transfers? Is government mainly transferring money from the young to the old? To what degree? In what way? By responding to these questions I provide important background information for the development of Generational Accounts as well as for a general understanding of the implications of an aging population.

Generational Accounting, as developed and discussed by Auerbach, Gokhale and Kotlikoff (1995), is used to examine the "sustainability" of fiscal policy, that is the net tax burden placed on future generations by the existing configuration of taxes and transfers. Generational Accounts assume that fiscal policy remains constant until the end of current generations' lifetimes, but that policy could change for future generations. To derive Generational Accounts, it is necessary to calculate the average tax payments and transfer receipts among generations for a base year. This exercise has been undertaken in Canada by Good (1995), Oreopoulos and Kotlikoff (1996), and most recently by Oreopoulos and Vaillancourt in Chapter 2. The two latter studies use Statistics Canada's Social Policy Simulation Database and Model (SPSD/M) to derive taxes and transfers by age and gender. My paper, which is also based upon these data, informs the Generational Accounting literature by examining the base year taxes and receipts in detail. I fill in several gaps in the SPSD/M by supplementing it with other Statistics Canada data and, just as importantly, point out methodological difficulties inherent in the calculation of the incidence of taxes and transfers across individuals at a point in time.

Attention has also been focused on the sustainability of government programs in the face of an aging population. Many of these studies use dependency ratios (the number of elderly and children over the working age population), and combine the demographic effects with economic effects and changes in program costs. For example, Fellegi (1988) concludes that changes in labour force participation and fiscal spending are more important than the demographic effects of the aging population when analysing the sustainability of government programs. Murphy and Wolfson (1992), and Henripin (1994) also study these issues and reach different

⁸⁷ Hwong, T. (York University, Canada) and L. Plager (Statistics Canada), "Income Distributional Outcomes of Converting Non-refundable Credits to Refundable Credits in Canada", *International Microsimulation Association 2009*, Abstracts – Session 3G, <http://www.statcan.gc.ca/conferences/ima-aim2009/session3g-eng.htm>.

conclusions. These exercises often emphasize that health care costs, due to their importance for the elderly, will be an important factor as the population ages. By examining the age profiles of the Canadian tax and transfer system in 1995 I provide more information for studies of this kind⁸⁸.

Results :

The main results show that though net transfers are positive for the young and the old, average transfers per capita are much larger for the old. The federal government transfers money, for the most part, to the old, whereas provincial and local governments transfer money to both young and old. Given an aging population this may indicate that the two levels of government will have to deal with different fiscal issues in the future. The analysis also highlights the methodological difficulties inherent in attempting to allocate taxes and transfers by age. In particular, the results are sensitive to the assumptions made concerning the intra-household allocation of taxes and transfers, and thereby suggest that more attention is needed in linking Generational Accounting to models of the family⁸⁹.

5. *The Impacts of Changing Tax/Transfer Systems on the 'Lifetime' Distribution of Net Taxes: 1984 to 1995*

Paper's introduction:

My objective is to examine the impacts of changes in the Canadian tax/transfer system on the age distribution of net taxes paid to federal and provincial governments. To establish a baseline the observed changes from 1973 to 1995 will be presented. The main approach is then to hold constant the structure of the Canadian population in 1988 and impose the tax/transfer systems of 1984 through 1995 as if they had been in place in 1988. As such, net taxes measures the impacts of tax/transfer changes independent of population and economic changes. Similarly, the research will hold constant the 1988 tax/transfer system and examine the impacts of variation of employment levels and cohort effects on the 'lifetime' distribution of net taxes by age.

I begin with a brief discussion of the inherent difficulties in measuring intergenerational equality in relation to the tax/transfer system, and then outline the changes to the tax/transfer system that have occurred from 1973 through 1995. This is followed by a description of the data sources, modelling techniques and general approach taken in the analysis. Finally, the results are presented⁹⁰.

Results:

I find that the net tax burden on the middle aged has increased while the burden on both the young and the old has decreased. While the age distribution of average net transfers has clearly been affected by changes to the structure of the tax/transfer system, these effects are overwhelmed by the larger magnitude of business cycle effects. The primary policy factor driving the changes of the past decade is not intergenerational equity or even age, but rather the deficit reduction imperative

⁸⁸ Hicks, C., February 1998. "Chapter 4 : The Age Distribution of the Tax/Transfer System in Canada", in *Statistique Canada, Catalogue no.68-513-XIB, Government Finances and Generational Equity*, <http://www.statcan.gc.ca/pub/68-513-x/68-513-x1997001-eng.pdf>, p. 39.

⁸⁹ *Idem.*

⁹⁰ Murphy, B., February 1998. "Chapter 5: The Impacts of Changing Tax/Transfer Systems on the 'Lifetime' Distribution of Net Taxes: 1984 to 1995", in *Statistique Canada, Catalogue no.68-513-XIB, Government Finances and Generational Equity*, <http://www.statcan.gc.ca/pub/68-513-x/68-513-x1997001-eng.pdf>, p. 57.

combined with a goal of making the deficit reduction policies as fair as possible by trying to mitigate the impacts on the poor⁹¹.

Chapter 11: Experimental Economy Theoretical Growth Model (XEcon)

Designer: Statistics Canada

Description:

XEcon (for eXperimental Economy) is a dynamic microsimulation model of an agent-based economy, populated with boundedly rational individuals and firms, and a statistician. In contrast to the other microsimulation models produced by Statistics Canada, XEcon is intended for theoretical exploration rather than practical empirical application. Nevertheless, it is intended that its results will shed light on current empirical issues.

A series of XEcon models is under development at the Social and Economic Studies Division in Statistics Canada. The current version of the XEcon simulation model available here allows you to replicate and extend the results in M.C. Wolfson, "New Goods and the Measurement of Real Economic Growth", *Canadian Journal of Economics*, Volume 32, No. 2, April 1999⁹².

User:

- Wolfson, Michael C. (Statistics Canada)

Applications:

1. *New Goods and the Measurement of Real Economic Growth*

Paper's Introduction:

Measured economic growth has slowed in advanced economies since the mid 1970s. A number of explanations have been advanced, one being that the slowdown is an artifact of the statistical system. In particular, one suspected source of error is the way the statistical system deals with the new kinds of 'information' products that are central to the current wave of technical change. These goods are often produced with dramatic and historically unprecedented increasing returns to scale.' Hence, their introduction is followed by a considerable period of falling prices, much of which may be going unmeasured given the usual lags before new products enter the

⁹¹ *Idem.*

⁹² Statistics Canada, *Experimental Economy Theoretical Growth Model (XEcon)*, <http://www.statcan.gc.ca/spsd/XEcon.htm>.

commodity baskets on which price deflators are based. In addition, there is a general sense that the pace of technical change has been accelerating. The conjecture is that the benefits of this very novelty and the increased range of choice are going unmeasured, and that these factors are becoming more important over time (Diewert and Fox 1997).

A number of analyses have sought to quantify the extent to which new goods are a source of bias in price measurement, and also, therefore, in the measurement of 'real' (i.e. deflated) economic growth (e.g. Diewert 1996; Griliches 1996; U.S. Senate (Boskin et al.) Advisory Commission 1996; Crawford 1993). The consensus is that there is an upward bias on the order of half a percent per annum. However, the Boskin commission considered only the 'product cycle' biases a rising from unmeasured price declines that occur after a commodity first appears on the market. Their estimates do not include any measure of the novelty of new goods as such, nor the effects due to differential impacts by income group. To aid our thinking, we have constructed a simplified model of an economy, and then used this to explore the effects of introducing new goods on various measures of real economic growth⁹³.

2. *XEcon: An Experimental / Evolutionary Model of Economic Growth*

Abstract:

The role of technical innovation in economic growth is both a current matter of keen public policy interest, and active exploration in economic theory. However, formal economic theorizing is often constrained by considerations of mathematical tractability. Evolutionary economic theories which are realized as computerized microsimulation models offer significant promise both for transcending mathematical constraints and addressing fundamental questions in a more realistic and flexible manner. This paper sketches XEcon, a microsimulation model of economic growth in the evolutionary tradition⁹⁴.

⁹³ Wolfson, M.C., "New Goods and the Measurement of Real Economic Growth", *The Canadian Journal of Economics / Revue canadienne d'Economie*, Vol. 32, No. 2, Special Issue on Service Sector Productivity and the Productivity Paradox (Apr., 1999), pp. 447-470, <http://www.jstor.org/stable/136431>, p. 447.

⁹⁴ Wolfson, M.C., "XEcon: An Experimental / Evolutionary Model of Economic Growth", *Statistics Canada and Canadian Institute for Advanced Research*, No. 67 June 1995, <http://www.statcan.gc.ca/pub/11f0019m/11f0019m1995067-eng.pdf>, p. 3.

Chapter 12: Other Models

Designer: W. K. Evans, M. Wolfson, W. Flanagan, J. Oderkirk, J. R. Goffin, J. Shin, G. Lockwood; Juravinski Cancer Centre, Hamilton, ON, Canada; University of Ottawa, Ottawa, ON, Canada; Statistics Canada, Ottawa, ON, Canada; Canadian Partnership Against Cancer, Toronto, ON, Canada, 2011.

Description:

Presentation's Abstract:

Background: Fiscal constraint is forcing decision-makers to make choices about which cancer control initiatives to fund in publically funded health care systems. A Cancer Risk Management (CRM) model has been developed for the Canadian Partnership Against Cancer as a web enabled platform to support health policy decision-makers.

Methods: The CRM uses dynamic, longitudinal microsimulation techniques to simulate and project realistic, representative populations. Each disease-specific module interacts within a single framework that incorporates Canadian demographic characteristics (births, mortality, immigration, emigration, interprovincial migration), educational status, risk factors (smoking, radon exposure, other as appropriate to the disease being modelled) and economic factors (earnings, taxes, government transfers). CRM utilizes current data lung cancer (LC) and colorectal cancer incidence, disease management and case fatality in Canada to assess impacts on population health and the cost to the health care system. Data sources include large national surveys, cancer registries and census data, as well as medical literature and expert opinion.

Results: The CRM has simulated the impact of prevention strategies for LC, adjuvant therapy for resected LC and new therapies for advanced disease. For example, a 50% reduction in current smoking prevalence could result in a 10% reduction in lung cancer incident cases at 10 years and result in a cumulative direct health care cost saving of \$215 M in Canada. The recent identification of a 20% mortality reduction using low dose computerized tomographic screening in high-risk individuals will be modeled using this platform once the full publication of results is available, including details of the frequency of investigation for false positives and the interventions utilized to investigate these cases.

Conclusions: The CRM will likely become a key resource to Canadian decision-makers as fiscal constraints and new screening and treatment approaches increasingly come into conflict with each other⁹⁵.

⁹⁵ Evans, W. K., M. C. Wolfson, W. Flanagan, J. Oderkirk, J. R. Goffin, J. Shin, G. Lockwood, "Cancer Risk Management Model (CRMM)", *2011 ASCO Annual Meeting*,

User: N/A

Applications: N/A

The Physical Activity Simulation Static Model (PASSM)

Designer: Statistics Canada

Description:

Developed with the Public Health Agency of Canada, Statistics Canada has developed evidence-based simulation tools to study the impact of physical activity on population health outcomes, with the ability to test different scenarios.

The Physical Activity Simulation Static Model (PASSM) explores the physical activity associated with activities of daily life, with scope for increasing physical activity (given 24 hours per day) and observing resulting changes in mortality and life expectancy.

A dynamic model explores patterns of physical activity over the life course and their impacts on health. This model enables users to view the future impact on population health of different

A dynamic model explores patterns of physical activity over the life course and their impacts on health. This model enables users to view the future impact on population health of different physical activity scenarios⁹⁶.

Users: N/A

Applications: N/A

Microsimulation of language use at home in a multilingual region with high immigration

Designer: INRS – Centre Urbanisation Culture Société, Alain Bélanger, Patrick Sabourin

http://www.asco.org/ascov2/Meetings/Abstracts?&vmview=abst_detail_view&confID=102&abstractID=78941.

⁹⁶ Statistics Canada, *Publications – Microsimulation – Health Models*, <http://www.statcan.gc.ca/microsimulation/health-sante/health-sante-eng.htm#a5>.

Description:

Québec is the second largest Canadian province and the only one with a French speaking majority. The province has a little under 8 million people, 79% of which having French as its mother tongue. Like many western countries, Québec is facing, in the coming decades, declining, and perhaps negative, natural increase and rapid population aging. Partly in response to those demographic challenges, Québec has increased its immigration intakes.

The composition of international immigration is increasingly diversified in its ethnocultural and linguistic characteristics. According to the 2006 census, 81 % of the Québec population declared French as the language most often spoken at home, but this proportion reached 88 % among its native born population and as low as 31 % among its immigrant population.

New immigrants have to learn either one or both of French (official language at the provincial and federal level) and English (official language at the federal level) to fully integrate to the host society. In this context, their linguistic choices will have an increasing impact on the linguistic composition of Québec's population, which is an important political issue. The aim of this paper is to build a dynamic model based on the Modgen microsimulation programming language. The model will include a module assessing language shifts over life course. Linguistic composition of the future Québec population will be projected up to 2051 for different scenarios. Stable populations will also be derived for all scenarios⁹⁷.

Users: N/A

Applications: N/A

Modelling and Simulation of Survey Collection Using Paradata

Designer: Kristen Couture, Yves Bélanger, Elisabeth Neusy (Statistics Canada)

Description:

In recent years, the cost of survey collection has grown significantly and nonresponse has increased. To counter these trends, strategies are being studied to optimize collection activities, resulting in a more time efficient and cost effective survey collection process. For example, recent initiatives for Computer Assisted Telephone Interviewing surveys at Statistics Canada include experimenting with time slices, limiting the number of calls, and establishing calling priorities. Field testing new procedures however has its drawbacks: it is costly and it is difficult to control, which can render the results difficult to interpret. To address these issues, we describe in this paper the creation of a microsimulation system of the collection

⁹⁷ Bélanger, A. and P. Sabourin, "Microsimulation of language use at home in a multilingual region with high immigration", *Microsimulation and Policy Design, 3rd General Conference of the International Microsimulation Association Stockholm, Sweden, June 8th to 10th, 2011*, http://www.scb.se/Grupp/Produkter/Tjanster/Kurser/Dokument/IMA/Sabourin_Belanger_FINAL.pdf

process which uses paradata as input. We discuss characteristics of the model as well as results of simulation runs with various parameters⁹⁸.

Users: N/A

Applications: N/A

Modeling large interacting populations in continuous time: A novel computational approach using Modgen

Designer: Claude Charette and Steve Gribble (Statistics Canada)

Description:

Large interacting populations are typically modeled using discrete time microsimulation. Continuous time microsimulation has a number of appealing advantages, including the ability to represent 1) continuous processes without approximation, 2) realistic causal relationships between and within individuals, and 3) processes with different time scales. On the other hand, the simulation of large interacting populations in continuous time can be programmatically complex. Moreover, the time required to compute does not scale well with population size in typical implementations. This paper presents a novel approach to the simulation of large interacting populations in continuous time that results in near-linear scaling of computation time with population size. The approach is illustrated using a simple infectious disease model implemented in Modgen, a general-purpose microsimulation platform⁹⁹.

Users: N/A

Applications: N/A

Pharmasim

Designer: Health Canada

Description:

⁹⁸ Couture, K. and Y. Bélanger, Neusy, *Modelling and Simulation of Survey Collection Using Paradata*,

http://www.amstat.org/sections/SRMS/proceedings/y2010/Files/308026_59879.pdf.

⁹⁹ Statistics Canada, “Modeling large interacting populations in continuous time: A novel computational approach using Modgen”, *International Microsimulation Association 2009, Abstracts – Session 2D*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session2d-eng.htm#a8>.

OBJECTIVES: The Pharmasim micro-simulation model has two closely related objectives. The first is to estimate the benefit that a Canadian family/individual would receive as a consequence of implementing various hypothetical national drug insurance plans (pharmacare). The second is to estimate the federal and provincial costs associated with implementing such drug plans. We demonstrate the capability of the model through a specific example.

DESIGN: We have developed a micro-simulation model with a synthesized micro database. The required database was created by statistically merging the Survey of Household Spending to the Survey of Labour and Income Dynamics for health related expenditures information. Imputed variables containing information on drug coverage, drug utilization and tax deduction/credit variables from the National Population Health Survey, private Brogan data, Régie de l'Assurance Maladie du Québec data and Ontario Drug Benefit data further enhance this merged database. Assembling these disparate data sources involves various statistical techniques such as statistical matching, logistic regression and Monte Carlo simulation. The federal/provincial tax routines and provincial drug programs are also incorporated. The model operates on this unique and comprehensive database to analyze the impact of new drug policies on households and government expenditures.

OUTPUTS/RESULTS: This micro-simulation model is applied to drug expenditure data to evaluate possible drug insurance schemes. The model allows estimating the revenue impacts of a suite of possible proposals and also assessing the distributional impacts on households from policy changes, including winner/loser analysis.

IMPACTS/OUTCOMES/CONCLUSIONS: The Pharmasim model provides information to better inform policy makers in selecting optimal national and/or provincial pharmacare plans¹⁰⁰.

User: N/A

Applications: N/A

Retirement Microsimulation Model

Designer: Jeff Carr and André Léonard (HRSDC Canada)

Description:

A microsimulation model of retirement decisions has been constructed and is being updated to allow the study of a variety of policy proposals for changes to the public and private pension systems. The model contains 1500 different types of individuals based on gender, age (individual years of age from 55-64), education level (less than

¹⁰⁰ Nguyen, L. and A. Gupta, "A microsimulation Model To Evaluate Hypothetical Drug Plans", *Books of abstracts – 2006 Health Canada Science Forum Proceedings, Health Canada*, http://www.hc-sc.gc.ca/sr-sr/pubs/about-apropos/forum/2006-boa_ldr-05-eng.php#a2_08.

Chapter 12: Other Models

high school, high school/college, university), income group (11 different groups), and pension plan type (public DB, private DB, other). Each of these representative individuals makes employment decisions based on their entire future income stream including their private pension income, private savings, as well as any public pension (CPP, OAS/GIS) income they might receive. Individuals also include the value of leisure time in their decision making their retirement decision ultimately about more free time or more income. All income is included after-tax.

This paper will explore the relative impacts of various public and private pension system revisions. The results will provide insight on the macro implications of these policies on the labour market behaviour of older Canadians as well as allowing for the distributional analysis of the policy impact in terms of labour force behaviour, income, and utility for various segments of the Canadian population¹⁰¹.

Users: N/A

Applications: N/A

¹⁰¹ Statistics Canada, “Retirement Microsimulation Model”, *International Microsimulation Association 2009, Abstracts – Session 2D*, <http://www.statcan.gc.ca/conferences/ima-aim2009/session2d-eng.htm#a11>.

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